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THE FRANKLIN INSTITUTE.

(Stated meeting held Wednesday, October 17th, 1906.)

Legislative Engineering.

BY JOHN C. TRAUTWINE, JR.

By "Legislative engineering," I mean engineering by legislative bodies composed of laymen, as distinguished from engineering by engineers.

Directly or indirectly, all public works are under the charge of the public itself. But there are differences in the degree of directness, in the extent to which control of the works is delegated by the public to specialists, and in the manner in which such delegation is secured.

This delegation of control may come about either by choice or by compulsion.

In despotic countries it is brought about by compulsion. The public is not asked whether or not it will delegate the control of its works to specialists. But, as civilization advances,

and as the magnitude and complexity of public works increase, the people appreciate more and more the advantages and the necessity of delegating the control of the works to those better qualified to conduct them than the public at large can possibly be.

Hence, in civilized countries, the delegation of control comes about by the choice of the people. No one thinks of calling a town meeting to decide upon the location of a fire hydrant. But the question still remains, to whom and to what extent shall the control be delegated?

In Philadelphia, as in most other places, the control of public works was early delegated to a body of laymen, selected to represent the people and in Councils assembled, and the Councils, in turn, appointed officers, supposed to be specially qualified to supervise the works. These officers carried out the instructions of the Councils.

If the Councilmen had had the intelligence to recognize, and the moral strength to avow, their limitations, all might have been well. But, even in their early days, we find the City Councils indulging in the pastime of hampering the experts in charge of the works, either by actual interference or by the simpler and always fashionable method of starvation.

Thus we find Benjamin H. Latrobe, the engineer who built our city's first water works, writing, in November, 1804, to Nicholas I. Roosevelt, who built the pumps in those works:

"First, the subcommittee of the Watering Committee must assent to an arrangement,—then comes the Watering Committee itself—then the Common Council, and the Select Council,—all avaricious, unjust, ignorant and proud."

The hundred years' history of the Philadelphia water works, from their completion in 1801 to the present time, is a striking monument of the folly of permitting the legislative branch to hamper the operations of the executive.

More than twenty years ago, namely, on June 1, 1885, a few men, zealous for the city's interests, and recognizing the hopelessness of the then existing system, succeeded in having passed through the Legislature, and signed by the Governor, the City Charter, known as the Bullitt Bill.

I ask your attention especially to the following provisions of this charter:

"The executive power shall be vested in the mayor and in the departments authorized by this act."

"Water works * * * shall be under the direction, control, and administration of the department of public works."

"Councils shall, by general ordinances, provide for the proper and efficient conduct of the affairs of the city by the mayor and several departments, and the boards thereof, but they shall not pass any ordinances directing or interfering with the exercise of the executive functions of the mayor, departments, boards, or heads, or officers thereof."

Here, in so far as a layman may presume to read and understand a legal document, the city charter not only distinctly forbids direction of, or interference with, the administration, by Councils, but as distinctly lays upon Councils the duty of finding the means for carrying out the plans of the administration for carrying on the city work.

Not only does the law make these provisions, it is to the interest of the city that the law should be enforced.

During Mayor Warwick's administration, and the early months of the next administration, I had the honor of trying to serve the city as the Chief of its Bureau of Water.

I quote as follows from my annual reports of that period:

1895.—"During recent years, the pumping machinery has been driven to its utmost, and it has been impossible to give it the advantage of that systematic and thorough repair which it so urgently needs."

1896.—"While we have thus far escaped the disaster of widespread conflagration, it cannot be long before the restriction of the supply by reason of inadequate mains, must become a serious menace to the thickly settled and poorly supplied business portions of the city.

"The No. 4 Worthington high-duty pump, removed in 1894 from Spring Garden to Belmont, remains without other protection than the rude house of boards placed over it by employees of the Bureau, and, owing to lack of proper boiler facilities, we have been unable to economize in fuel by using the high-duty attachment.

"At Belmont and at Roxborough high service stations, we are dependent upon one pump, any accident to which would

throw the station out of service, and deprive the district of water."

1897.—"The water service of this city is in a critical condition.

"Between continued starvation, on the one hand, and enormously increasing waste on the other, it is made to appear, as stated in your report of 7th October last, that we are compelled to negotiate with corporations and individuals to secure, for the citizens of Philadelphia, a pure and abundant supply of water.

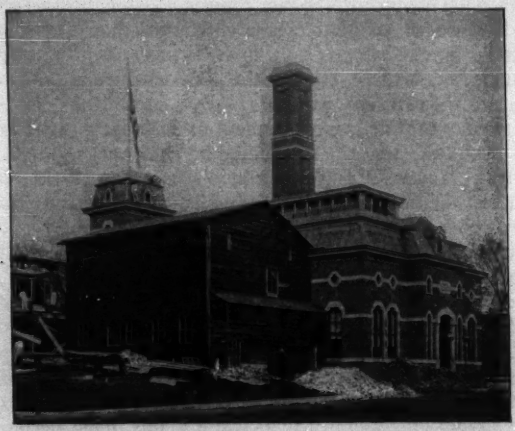


Fig. 1—Temporary frame shed, protecting high-duty pumping engine at Belmont, 1895 to 1899. Appropriation for proper protection refused.

"As a matter of fact, the city holds in her own hands the key to the solution of her water problem.

"The consumption has again overtaken our pumping capacity; and there will, almost certainly, be a shortage of water at many points during the coming year."

1898.—"The large high-duty pumping engine at Belmont station still remains protected only by a rude frame house erected over it by employees of the Bureau in 1895, our appeals, (repeated in 1895, 1896, 1897 and 1898), for the few

thousand dollars required for its proper protection, having been refused.

"In each of my four annual estimates, I have asked for $35,000 for the construction of proper coaling facilities for the Queen Lane pumping station. The appropriation having been annually refused, we are compelled to haul the coal through the park in carts, at an annual additional expense of about $9,000."

At the time, the slender engineering force prepared detailed plans for the needed coaling facilities.

In the face of these quotations, it will hardly be claimed that the legislative branch was not advised as to the conditions and needs of the works.

The following statement shows (1st) these needs, and (2nd) the extent of the appropriations granted by the legislative branch, in response to the representations of the executive:

ESTIMATES AND APPROPRIATIONS.

For Extensions.

	Estimates.	Appropriations.
For 1896	$2,484,150	$0
" 1897	3,339,450	0
" 1898	3,735,050	0

It will be noticed that, naturally enough, the estimates for extensions and improvements increased from year to year, as the demand for water increased, and as all appropriations for meeting this demand were withheld.

You will recollect that their honorable bodies were strongly minded to pass an ordinance appropriating $50,000,000 or thereabouts to the Schuylkill Valley Water Company, in consideration of a "snake" which that Company proposed furnishing to the city, and that the scheme was frustrated only by the timely or untimely exposure of extensive bribery operations, which had resulted in the purchase of many of the city's representatives.

I had devoted all the time at my command to exposing the worthlessness of the Schuylkill Valley Water Company's scheme, but these considerations seemed to have not the slightest weight with the City Councils.

In 1898, $500,000 were appropriated "for the purpose of constructing a reservoir, furnishing pumping machinery and

mains for that portion of the city lying west of the Schuylkill River;" notwithstanding that it had been shown that the existing pumping machinery was unable to keep even the small old reservoir full of water, and that it had been found necessary to cut off that reservoir from the distribution in order to keep in it any water at all.

An appropriation of $25,000 was made also for the purpose of cleaning the reservoir, notwithstanding that it had been pointed out that the accumulation of sediment in the reservoir

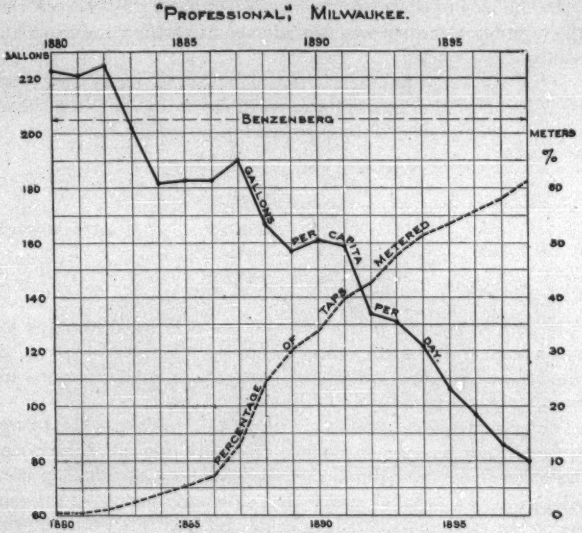


Fig. 2

showed that the water was *depositing* it there, and *not taking it up*, and that, if the reservoirs were cleaned to-day, they would have in them, to-morrow, a deposit of exactly the same material.

The contrast between legislative and professional engineering is well shown in the comparison between the experiences of Milwaukee and Philadelphia.

In Milwaukee, from 1880 to 1898, under the strong manage-

ment of Mr. George H. Benzenberg, the percentage of taps metered was increased from practically nothing to 61 per cent., the daily per capita consumption falling, in the meantime, from 220 to 80 gallons.

In Philadelphia, during the same years, and under the legislative system, the percentage of taps metered remained practically at zero, and the daily per capita consumption increased from 68 to 225 gallons.

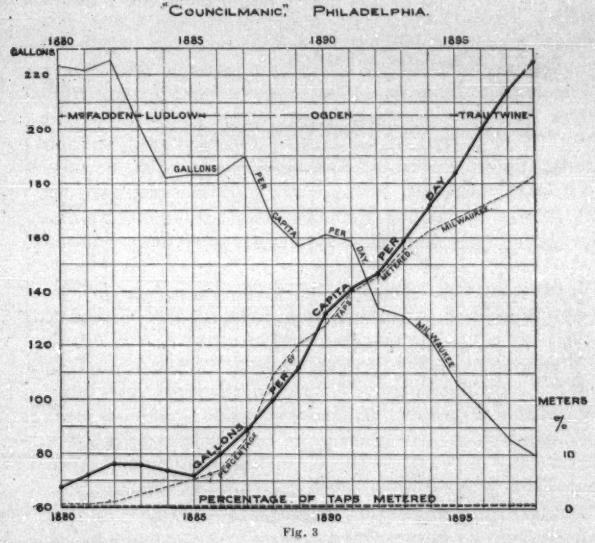


Fig. 3

The next two figures, representing Milwaukee and Philadelphia respectively, show the contrast still more forcibly.

Here the percentage of taps metered are plotted as abscissas instead of the years, as in the figures above.

It will probably be objected to these figures of consumption, as applied to Philadelphia, that they are exaggerated. Every little while, someone discovers that the pumps in Philadelphia are not raising all the water which is claimed for them, and the Bureau of Water is held up to public scorn for "falsifying its

reports." Whereas everybody knows, and the Bureau is constantly insisting, that the figures are known to be exaggerated, and that this is because of the lack of proper facilities for measuring correctly the quantities raised by the pumps.

Naturally, I have drawn largely upon my own experience in the foregoing recital, but it is not to be supposed that my complaint is a personal one, or that I alone have been the sufferer.

During the years 1880 to 1898, three others besides myself had charge (more or less nearly nominal) of the water works,

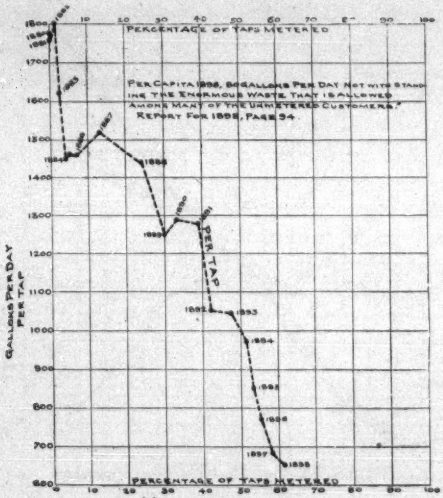


Fig. 4

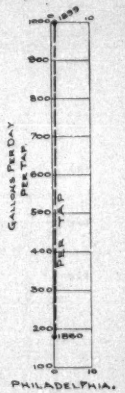


Fig. 5

and since my administration, both Mr. Hand, in the Bureau of Water, and Major Gillette, in the Bureau of Filtration, have had experience of the pernicious activity of the City Councils in meddling with the public works.

In transmitting to Councils his report for 1885 Colonel William Ludlow, Chief Engineer of the Philadelphia Water Works, said:

"I regret that the termination of my official connection with

city affairs and present departure for another field of duty, leave me without adequate time or opportunity to enhance the possible usefulness of this report by formulating therein certain detailed statements and discussions relating to the water service of the city, additional to those which have heretofore been presented; but the apprehension of a duty in this respect partially unfulfilled is tempered by the consideration that my reports for the years 1883 and 1884 contain a large body of important data and recommendations, of which the greater part still remain unacted upon, and that if the conduct of affairs in the future shall proceed with the deliberateness which has marked the securing of urgently needed improvements in the past, so protracted a period will be required for their practical execution as to render superfluous any material additions thereto at the present time."

Upon the assumption of office by the late Mayor Ashbridge, the city purse-strings, for reasons best known to the city fathers themselves, were suddenly and freely loosed; and, in his first annual report, that dated January 20, 1900, we find Chief Hand saying:

"The appropriations granted during the past year provide adequate means to avert serious disaster, and to remove some of the critical features of the works, which for several years, have been sources of great anxiety. This condition is very gratifying, especially when it is remembered that, for the last three summers, it has been difficult, owing to insufficient appropriations for needed extensions, etc., to prevent absolute water famine in some districts."

So striking was the contrast between the new conditions and the old, that Chief Hand found deep cause for thankfulness in the ability "to avert serious disaster, and to remove some of the critical features of the works."

But any city, following the antiquated practices adopted for Philadelphia by their Honorable Bodies, will find its facilities constantly overtaken by the growing consumption; and the lavishness, which enabled Chief Hand "to avert serious disaster" in 1899, seems to have waned very shortly thereafter, as witness the following quotation from his reports, for 1903 and 1904:

1903.—"Urgent recommendations were made for appro-

priations with which to purchase new engines, boilers, and other appurtenances necessary to furnish a sufficient supply of water during the heated term and during extremely cold weather, but, I regret to say, that no provision has yet been made for these important purposes.

"No appropriations whatever were made for extensions during 1902 nor 1903, and no such provision has since been made for 1904.

"The delay in making important additions to the pumpage systems, necessitated, from time to time, by the growth of the city, and the proportionate increased requirements of its water supply, can only lead to additional crippling of the service by overworking the machinery.

"The water supply has been maintained throughout the city as effectively as the water facilities at my command would permit."

1904.—"The above predictions of 1903 have been abundantly verified by numerous and serious breakdowns of the pumps and engines at all our large stations, crippling the service to such an extent that in some instances weeks, and even months, were required to make the repairs.

"Extensive repairs are needed to all the machinery at this station (Queen Lane), but it is impossible to make them, owing to inability to shut down for a sufficient length of time to prosecute the work thereon.

"This bureau has been very much hampered by lack of funds with which to purchase and lay service mains in all parts of the city."

Yet, upon the occasion of a recent Councilmanic visit of inspection, these gentlemen expressed themselves as aggrieved because they had not been kept informed as to the conditions and needs of the works.

In March last, Major Gillette informed Councils that the immediate placing of a water meter on every tap in the city, at a total cost of about $5,000,000, would save to our people about $10,000,000, namely: $4,000,000 in cost of completing the works, and $6,000,000 in capitalized cost of pumping, besides hastening the day of filtered water.

Whereupon their Honorable Bodies resolved, with practical unanimity,

"That we unqualifiedly enter our protest against the use or installation of water meters in connection with the water supply of the city.

"That we stand ready and willing to vote all the funds necessary for the perfection of our water supply and the completion of the entire system of filtration, but not for one dollar toward the purchase or installation of water meters in connection with that system."

Their motto evidently was:—"Millions for tribute—but not one cent for defense."

These utterances brought forth the following editorial comment from *Engineering News*, the foremost engineering periodical of the country:

"The resolutions afford so striking an example of popular prejudice and ignorance that they are well worth putting on record for the benefit of engineers and city officials elsewhere."

In a recent interview, solicited by a reporter of the *Public Ledger*, I gave expression to my views on this subject, and I regretted to find my remarks prefaced by the headlines: "Blames Councils for Poor Water Supply."

In his domestic and business capacity, the average Councilman is a harmless and necessary creature. So, Shakespeare informs us, is the domestic cat, yet we do not upon that account place the cat in charge of the canary bird.

It must not be supposed that the writer is engaged in a tirade against municipal legislators in general, or against those of Philadelphia in particular. City Councils are generally large and mixed bodies, composed almost or quite exclusively of laymen. Some of these laymen, in Philadelphia at least, are men who would do honor to any legislative assembly, men with sufficient intelligence to recognize their limitations, and sufficient moral strength to avow them; men who realize that professional questions should be referred to professional men, and who would secure such reference if they could. But the rank and file are made up largely of young men without visible means of support other than their Councilmanic seats, which have been given them by the "leaders" as compensation for services performed or expected, or both, and who themselves in time develop into professional politicians and "leaders." Politicianism is their business, and upon what can be made out

of it they depend for their livelihood. In most cases the dear people (by order of the "leaders," of course,) have repeatedly and enthusiastically returned these gentlemen to their seats by overwhelming majorities, no matter how notorious has been their disregard of the public welfare. Who, then, can blame them if they industriously ply that vocation to which the sovereign people have called them?

The writer asks merely whether it is well that these bodies, in defiance of the City Charter, should be intrusted, by the people, with the control of public works; and the City Councils of Philadelphia have done service to the cause of good government by demonstrating, in the examples before us, that it is not.

In this connection, I quote as follows from remarks by Mr. Edwin F. Smith, Chief Engineer of the Schuylkill Navigation Co., published in 1899:

"Here we have a governing body of nearly two hundred men, 'butchers and bakers and candlestick makers,' professional politicians, few of whom have not an axe to grind, caring little whether they serve the interests of this great city or not, so long as their bread is buttered on the right side.

"The remedy is to take this water question out of Councils. If it was ever intended under the Bullitt Bill that Councils should constitute themselves a Board of Engineers, and devise plans, legislate in the interest of schemers, and even do the detail office work of the Department of Public Works, it is a great mistake that it should be so, and the sooner it is changed the better for those who are still left among the living. I do not believe that it was the intention of the author of the Bullitt Bill that it should be so. If it was, why do not Councils plan the Delaware avenue improvements, the Reading subway, and other municipal work? Well, plainly it is either because there is no money in it for them, or because they are only experts in water works construction.

"When the Bureau of Water is given the same power and working force as the Bureau of Surveys, and when Councils keeps hands off everything except granting appropriations and legislating for the public safety, we will have relief from bad water."

Please bear in mind that these remarks come from an intelli-

gent and educated engineer of long experience and sound judgment, a man eminent for his conservatism, and in no way connected with the Bureau of Water.

THE PRODUCTION OF MICA IN 1905.

The production of mica in 1905 made an important advance over 1904, according to the annual report of the United States Geological Survey, which has been compiled by George O. Smith. Production was limited to six States—North Carolina, Colorado, New Hampshire, Georgia, South Dakota and New Mexico, the order named indicating their relative rank. The total output of sheet mica for these States, as reported to the Survey, was 851,000 lbs., with a total value of $185,900. Of this quantity North Carolina is credited with 669,000 lbs., valued at $85,000. The increase in production over the previous year was largely in other States, while the larger increase in value may be accounted for in part by high prices reported by producers in those States. A decrease in the average price for the North Carolina product is due to the increasing proportion of small mica produced for electrical uses. The total production of scrap mica in the United States in 1905 was 856 net tons, valued at $15,255, an increase in value over the production for 1904. North Carolina's output of scrap mica for 1905 was 175 tons, valued at $2,375. The separation of the production figures for scrap mica and for the smaller sizes of sheet mica becomes more difficult as the use of these small sizes increases.

The production of sheet mica in 1904 was 668,358 lbs., valued at $109,462, and of scrap mica 1069 net tons, valued at $10,854. Thus the value of the aggregated product of mica in 1905 was $201,155, as compared with $120,316 in 1904.

The value of imported mica now used in the United States is twice that of the domestic article. In 1905 1,506,382 lbs. of the unmanufactured mica, valued at $352,475, and 88,188 lbs. of cut or trimmed mica, valued at $51,281, were imported, making a total of 1,594,570 lbs., valued at $403,756.

The three principal uses of mica are for electrical insulation, glazing and decoration. The first-named application probably leads in present importance, but the other two uses date back to ancient times, mica antedating glass and also being early used to secure decorative effects.

The increasing use of mica in electrical manufacture has largely modified the demand made upon the mining industry. Small sizes of sheet mica can now be utilized in the manufacture of insulators in lamp sockets, lightning arresters, switch boxes and fuse blocks. More important even is the extensive use that is made of composite mica, micanite, molded mica and other varieties of built-up mica sheets. In the manufacture of material of this class thin laminæ of irregular form and different sizes are arranged and cemented together to form thick sheets of any desired size.

The use of mica for stove windows formerly constituted the principal demand for sheet mica, but this has decreased somewhat in recent years.

The increased use of sheet mica in incandescent gas lamps and for miners' lamps has kept up the demand for glazing grades, so that whatever comes into the market is readily bought. Sheet mica is also used to some extent for phonograph diaphragms and in various small boxes and other novelties.

Scrap mica is utilized in the manufacture of a superior quality of boiler lagging, a mat of finely-divided mica flakes furnishing a fireproof covering that has sufficient strength to be durable, not disintegrating like some other materials, and excelling asbestos and magnesia compound as a nonconductor of heat. The superiority of the mica lagging appears to depend not only upon the low conductivity of the material itself, but especially upon the loose texture of the mica mat.

Ground mica is used in somewhat increased quantities, the coarser grades in mica bronzes and paints and also as an absorbent for explosives. Ground mica also forms an ingredient in some heavy lubricants. The finest ground mica or mica flour finds a considerable market with the manufacturers of high-grade wall papers, the luster obtained by the use of the muscovite dust having the advantage of both permanency and brilliancy.—W. L. C. in *Iron Age.*

PRACTICAL HINTS TO QUARRYMEN.

The only slate region which has been geologically mapped is the western Vermont and eastern New York slate belt. Maps of quarries in this region are included in Bulletin No 275 of the United States Geological Survey, which is a recent report by Mr. T. Nelson Dale on the slate deposits and slate industry of the United States.

These quarry maps are designed to be of practical utility. The coloring shows where the Cambrian green and purple and the Ordovician red slates may be looked for or not looked for. The course of bedding and cleavage has been shown at several quarries by special symbols. The scale of the maps is sufficiently large to admit the entry of many more quarries and symbols. By using a small geological compass to determine the strike of any bed of good slate at any of the located quarries, and transferring it to the quarry maps by means of a protractor, the probable direction of the recurrence of the bed can be ascertained, and so with joints, hogbacks, or dikes. Such a compass should be provided with sights, spirit levels, and movable ring to set off magnetic variation, and have a clinometer attachment to indicate angle or dip.

Quarrymen are very skilled in detecting the presence of good slate from the peculiar appearance of the weathered edge surface. That skill appears to have been their only guide in prospecting in this region. Mr. Dale suggests that it would be well if it were re-enforced by the use of a certain method in exploration, which he outlines.

This bulletin, which should be of practical value to every quarryman in the country, is published for general distribution. It may be obtained, free of charge, by anyone who makes application for it.

(Stated Meeting, held Wednesday, November 21, 1906.)

The Survival of the Shortest and of the Easiest in Language.

By Edwin Swift Balch.

While it seems hardly within the province of the journals of the applied sciences and of commerce to discuss questions of philology, yet it might be wise for them to consider the recent action of the Simplified Spelling Board recommending a general adoption of three hundred somewhat shortened words, and also the fact that these words are to be used henceforth in some at least of the Government documents. The recommendation of the Board and the Government order amount merely to codifying or recognizing by statute certain changes which natural causes thru evolution have already brought about in the American language, and the questions to be discussed would seem to be: Should or should not the trade journals follow the recommendations which have already been made and which may be made in the future by the Simplified Spelling Board? Will the adoption of these recommendations be a commercial benefit?

The conservative view, which appears to be held by most Englishmen and also by many Americans is that—while admitting that for the expression of thought written English is an uncouth instrument which does not tally with spoken English—we should go on misspelling till the Crack of Doom because our forefathers did so. This theory is not only opposed to all the dictates of common sense, but it is opposed to the law of evolution. Everything everywhere is in evolution: the stars, the earth, humans, animals, sciences, arts: *"Tout lasse, tout casse, tout passe."* We no longer make darkness visible with rushlights, nor travel about in ox-carts, nor cross the ocean in a "Susan

Constant" or a "Discovery," but conservative people cling lovingly to a superannuated, antiquated spelling.

Language is no exception to the universal change; it is in constant evolution. Local languages, dialects tend to disappear and to be superseded by some more widespread tongue. The writer himself has been able to observe during his lifetime the retrogression of Norman and Breton *patois* before French and the increasing purity of the German spoken among the German peasants. Before the end of the twentieth century, probably only some fifteen or twenty great national languages will remain, where formerly almost every district had its own special mode of speech.

The greater languages themselves are also constantly receiving accretions of newly formed words, many of which have become or are rapidly becoming internationalized. These are principally words of travel, of commerce, or sport; such as hotel, telephone, sleeping car, photograph, beeksteak, restaurant, automobile. Many continental Europeans also often know imperfectly three or four languages and they frequently converse with foreigners in a sort of polyglot jargon. There is thus an evident tendency on the continent of Europe towards the eventual breaking down of the purity of the present languages into a curious conglomerate of them all. In other words, evolution is at work among the more widespread as well as among the local forms of speech, and if there is ever an universal language it will doubtless be the result of this evolution.

A purely ideal plan for improving languages would be to have a Commission or Board constituted of one or more philologists as representatives from each of the great nations. This Board could first agree on a common alphabet for all the great languages and then internationalize all new words concerning inventions and commerce, such as telegraph, invoice, etc. Commerce would certainly be much facilitated by some such arrangement, altho, owing to national prejudice, the chance of anything of the kind being done is about as remote from us, as was Emeric Crucé's dream in 1622 distant from its realization in the Arbitration Tribunal at The Hague in 1898.

In North America also language is evolving: American is evolving away from its parent English. Americans use many

terms differently from Englishmen and moreover they pronounce and accent them differently. In writing and printing the tendency in America is to shorten words and to spell them in the simplest way, so that the Survival of the Shortest seems to be the keynote to the evolution of language in America.

If the spelling of words is shortened, it will mean a saving of time, labor, space and expense in writing and printing. If the spelling of words is made more fonetik, there will be a saving of time, trouble, and mental suffering to school children in their studies, and it will also be much easier for foreigners to learn to read and speak our language. This facilitating the learning of the language would of course increase its employment and its spread, so much so in fact, that a fairly fonetik spelling might in time make American the universal language of commerce.

If our written and our spoken language are ever made to correspond, it will do away largely with the many vagaries of pronunciation now in use. We should no longer hear Eyetalians for Italians, tomehtoes for tomatoes, profeyele for profile and a thousand other such mispronunciations, which are the logical outcome of a mode of speech where the vowel a is miscalled eh, and the vowel i is miscalled eye.

In the case of adopted foreign words, if an accent were placed on the syllable to be emphasized, it would help to clarify our muddled pronunciation. Foreign words are often mispronounced, because the accent is misplaced. We say Sehéra, Himeléyas, Tokío, for instance, whilst those names should be pronounced Sáhara, Himálaya, Tókio. An accent would give a speaker some idea where to throw the emphasis.

The Germans, in many ways a better led nation than the English or the Americans, have two great commercial advantages; the metric system and a practically fonetik spelling. It saves probably a year's work to German children not having to memorize misspelt words and a ridiculous list of unintelligible weights and measures. The growing trade of the Germans shows their wisdom. And with their lines of steamers, their colonizing, their emigration, it is more than probable that the German language will supersede the English language in many parts of the world. This seems likely to be the case in South South America, and we shall have to thank partly our conserv-

atism, self-satisfied with an imperfect language and no system of weights and measures, if we let slip from us into German hands the commerce and the dollars of South America.

English has certainly had the chance of becoming the language of commerce. It is the language of North America, of South Africa, of Australia, of numberless small British Colonies, and it is understood in almost all sea ports. But the insuperable difficulty of the written English language giving so small a cue to the pronunciation militates to such an extent against it that it may be superseded commercially by some other tongue. It may finally prove that the newly invented Esperanto may offer the least resistance for the needs of commerce, but it is certain that the law of Evolution and Survival of the Easiest will eventually solve the problem.

It seems a pity for the English and American nations to block, thru sheer conservatism and inertia, any remaining chances our mother tongue has still of becoming the language of commerce and possibly the basis of an universal language in the future. And it would seem to be the part of wisdom for the trade journals to take spelling reform in hand and hasten the evolution of English into a more serviceable tool and a more easily learned method of conveying thought.

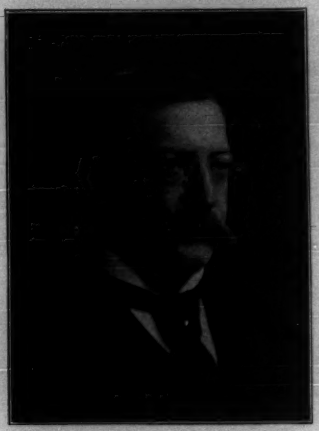
USE OF CALCIUM IN METAL REFINING.

In former experiments made with a view to refine copper, bronze, steel, pig iron, etc., by the aid of metallic calcium, the results were unsuccessful because the calcium was volatilized immediately after being placed in the metal, or burnt on the surface. The process recently invented by Brandenburg and Weins employs the calcium in form of turnings, instead of large lumps, and mixing with turnings or small fragments of one or more metals. This mixture of various metals in a solid form, e. g., brick, is placed in the liquid metal. To refine the latter at a high temperature, the calcium turnings are mixed with those of metals more difficult to fuse than calcium. Thus copper or copper alloy can be refined by mixing calcium, copper and bronze turnings, and molten iron or steel with calcium, iron and steel turnings. Metals can also be refined at temperature of fusion of calcium or lower, the calcium turnings being mixed with those of a more fusible metal, and the cakes or bricks formed from the mixture made to react. Cast-iron, already rather pasty, can be refined by employing, for example, calcium and aluminum turnings. The process was described in *Revue des Produits Chimiques*, Aug. 1, 1906.

IN MEMORIAM.

ROBERT COLEMAN HALL BROCK

was born in Philadelphia July 26, 1861, and was the fifth son of the marriage of John Penn Brock to Julia Watts Hall.



His grandfather's grandfather, John Brock, arrived in Philadelphia on May 3, 1682, on the ship "Friends' Adventure" (five months before the arrival of Wm. Penn on the "Welcome"), having before his departure from Chester, England, received from the Proprietary a grant of land situated on the Delaware River below Morristown, Penna. The original immigrant's grandson (and the grandfather of the subject of this sketch), who was born January 24th, 1792, served in the U. S. Army during the War of 1812, and later became one of the largest merchants of this city. He was one of the earliest purchasers of anthracite coal-lands in Schuylkill County in this State, and founded the town of Ashland.

Through his mother's family he is related to the Halls of Harford County, Md., and the Watts and Colemans, of Pennsylvania.

He began his education at Dr. Faires' school in Philadelphia, and continued it at St. Paul's, Concord, N. H., under the Rev Dr. Henry A. Coit.

Subsequently he entered Worcester College, Oxford University, England, whence he was called home before receiving his degree, by the fatal illness of his father, who died shortly afterwards.

He entered the law office of the Hon. George M. Dallas and was admitted to the bar in 1884. In this year also he married Alice the daughter of the late Henry C. Gibson, by whom he has had three children, two of whom and his widow survive him.

In 1888 he entered the firm of W. H. Newbold Son & Co., but retired in 1894 and traveled in Europe to restore his health which had become impaired.

He was already a member of the Historical Society (which he joined in 1883), the Franklin Institute (in 1889), the Rittenhouse Club (in 1890), and the Philatelic Society (of which he was President from 1886 to 1889, and which ceased to exist in 1890), before his journey to Europe in 1894.

Possessed of an alert and well-trained mind and a restless energy, on his return he threw himself with enthusiasm into the ranks of the active workers in additional fields of science, art, and humanity; for among other striking characteristics of Col. Brock was his benevolence, which made him ever ready by counsel, personal effort, and liberal pecuniary contributions, to alleviate want and suffering.

He joined the University Club in 1897; the Philadelphia Club in 1898; the Union League Oct. 18, 1905; the American Philosophical Society in 1899; the Archaeological Society of Penna. in 1901, serving as its President from 1903 to 1905 and as Vice-President till his death. In 1901 also he was elected a member of the Board of Managers of the Franklin Institute, which position also he held till his death, aiding by his excellent advice and generous aid in all its undertakings. We his colleagues know how quick and accurate were his conclusions on matters requiring care and judgment, and how ready he was to give financial help when it was needed.

He was made a member of the Philobiblon Society in 1903. He became a stockholder of the Academy of the Fine Arts, Sept. 1, 1901, and a Director in 1904, in which year also he was elected the Colonel of the 2d Regiment, N. G. P., holding these offices till his death.

In addition to the occupations which membership in the above organizations entailed, he was a Director of the Epileptic Hospital, in Oakbourne, West Chester, Penna.; a member of the Numismatic Society, (Feb. 2, 1882); of the Sons of the

Revolution (May 4, 1901,) and of the Art Club of New York till his death.

But all his energy was not consumed in serious responsibilities. His cheerful nature delighted in sports, and in the society of his fellows. He was an active member of the New York Yacht Club, and of the Corinthian Yacht Club of Philadelphia, and not only heartily enjoyed a yachtman's life but made himself master of the details of managing craft of all kinds.

He was also an enthusiastic automobilist from the date of the introduction of this machine; making many interesting tours and planning others more extensive, not all of which however he was able to carry out.

But the mere statement that he was active in all these associations does not indicate the energy with which he worked for them, the intelligence with which he guided their various policies (or assisted in doing so), and the liberality with which he supported them.

At the meetings, rarely missed, of the managing bodies to which he belonged, he was not content merely to vote "aye" or "no." He weighed every proposition and usually made excellent suggestions of modification or amendment. When the course of action was once decided upon, whether with or without the changes he himself had thought advisable, he was always ready to undertake his share (and generally accomplished more) of the drudgery of visits, collections, searches and all that the perfunctory member avoids and shirks.

Col. Brock's courtesy and gentleness of manner were as remarkable as his extreme modesty and kindness of heart.

He was frank and fearless, yet withal discreet and considerate. He was impatient of ambiguity and indirection, and nevertheless never harsh in judging those whose ethical standard was lower than his own.

He embodied the best type of useful citizen, one whose brains and hands were always at the service of his fellows for worthy objects; and of the American gentleman, exemplifying in his own conduct how a large fortune could be worthily enjoyed and at the same time used for noble purposes.

PERSIFOR FRAZER,
LOUIS E. LEVY,
ALEXANDER KRUMBHAAR.

VARIABLE SPEED TURBINE ENGINE.

A turbine has been patented in England which, by means of two sets of steam admission ports, into either of which steam may be admitted at will, it is claimed will give two different speeds of operation at the same efficiency. For the higher speed the steam is conducted from one set of ports through expanding nozzles to the rotor, where it encounters two sets of moving blades and one set of fixed blades, passing thence to the exhaust. For the lower speed, the steam takes the same path through the blades as before, and is then led from the second set of moving blades into a group of blades consisting of two fixed and two moving sets. This arrangement gives a speed about half that due to the other, the reason being doubtless that, the expansion being carried through a longer stage, the drop in pressure at each set of blades is but half what it was before, with consequent proportional speed factor.—*Iron Age.*

SMELTING ZINC ORE IN THE BLAST FURNACE.

The experiments on the smelting of zinc ore in the blast furnace by the Lungwitx process at Warren, N H., are shortly to be resumed and this season will be pushed to a definite conclusion, one way or another. It will be remembered that the physics of the process were recently discussed in two elaborate papers in the "Journal" by Mr. Gordon, chief engineer of the company which is testing the process. However, there are so many physico-chemical conditions involved in this problem as to which there are no available data, that it is impossible to arrive at any absolute conclusion from theoretical considerations, and the result must be determined by trial on a practical scale. Last year the work was unfortunately checked by a series of untoward accidents, which, however, were not unexpected in view of the boldness of the conception and entire novelty of the plant.—*Eng. and Min. Jour.*

LEAD PEROXIDE MANUFACTURE.

L. Frederich, E. Mallett and P. A. Guye, in *Monit. Scient.*, 1906, XX, pp. 514-518, state that normal or basic lead sulphate can be converted into lead peroxide with a nearly theoretical yield, by mixing it with magnesia, suspending the mixture in water, and passing in chlorine. In a trial with 5 kg. of lead sulphate in a rotating barrel of 25 liters capacity, the operation was completed in about three hours, and required: Water, 13 liters; magnesia, 1.2 kg.; and chlorine 1.2 kg. The crude reaction product obtained contains at least 90 per cent. of lead peroxide, and by purification first with caustic soda, and then with acid, a product of 97 per cent. purity can be obtained, containing only traces of chlorine. The cost of production of 100 kg. of lead peroxide is given as follows: 36 kg. of magnesia at 7 francs per 100 kg., 2.50; 3 kg. of chlorine at 15 francs per 100 kg., 4.95; 146 kg. of lead sulphate at 23 francs per 100 kg., 33.60; labor, etc., 3; total, 44.05 francs.—*Eng. and Min. Jour.*

ELECTRICAL SECTION.

(Stated meeting held Thursday, November 8th, 1906.)

The Physical Meaning of Power Factor and the Significance of a Power Factor Less Than Unity Without Phase Difference.

By Albert F. Ganz, M.E.,

Professor of Electrical Engineering at the Stevens Institute of Technology.

The power delivered to an electric circuit is at any instant equal to the product of the current strength in amperes, and the electromotive force or potential difference in volts, and this power is expressed in watts. With ordinary continuous currents the electromotive force and current strength remain constant for a finite time, and this constant electromotive force and current strength is indicated on a voltmeter and an ammeter suitably connected in the circuit. The product of the volts and amperes so indicated is the power in watts and is also constant.

With alternating currents the electromotive force and current strength are constantly changing in accordance with some periodic law. It is still true that the power is at any instant equal to the product of the volts and amperes at that instant. Alternating current voltmeters and ammeters do not indicate instantaneous values, but the *square root of the average squares* of these instantaneous values, which are called in practice the **effective* values. The average power is equal to the average of the products of the instantaneous volts and amperes, and

*In this article effective values of c. m. f. and current are designated by capital italics *E* and *I*, and instantaneous values by small italics *e* and *i*.

this average power in watts is in general less than the product of the effective volts and amperes. The factor by which this product of volts and amperes must be multiplied in order to obtain the true average watts is called the *Power Factor*. The true average power in watts can be directly indicated on a wattmeter suitably connected in the circuit. The Power Factor is then defined by the equation,

$$\text{Power Factor} = \frac{p}{I\,E} \tag{1}$$

and the simplest way to determine the Power Factor of an alternating current circuit is to measure I with an ammeter, E with a voltmeter and p with a wattmeter, and then to calculate the Power Factor by means of equation (1). The product of effective volts and amperes is generally called the *apparent power* or the *apparent watts*.

SINUSOIDAL WAVE FORMS.

The simplest and most common forms of electromotive force and current waves met in practice are sine waves. The effective value of a sine wave is equal to the maximum value, or amplitude, divided by the square root of two. In symbols,

$$E = \frac{e_m}{\sqrt{2}} \tag{2}$$

With sine waves of electromotive force and current the Power Factor is numerically equal to the cosine of the angle of phase difference between electromotive force and current. With sine waves we can therefore write for the equation for power,

$$p = E\,I\cos\theta \tag{3}$$

In most treatises on alternating currents sinusoidal waves are assumed, and Power Factor is often defined as the cosine of the angle of phase difference.

We shall first consider the physical meaning of Power Factor in a circuit with sinusoidal electromotive force and current.

Let an alternating current generator be connected to a receiving circuit so that an alternating current flows through the circuit, and that power is delivered to and consumed by the cir-

cuit. If the sinusoidal electromotive force and current are in phase the angle of phase difference θ is zero, and $\cos \theta = 1$, and therefore the Power Factor is unity. The electromotive force, current and power curves for this case are shown in Fig. 1.

The power curve is a sinusoid of twice the frequency of the

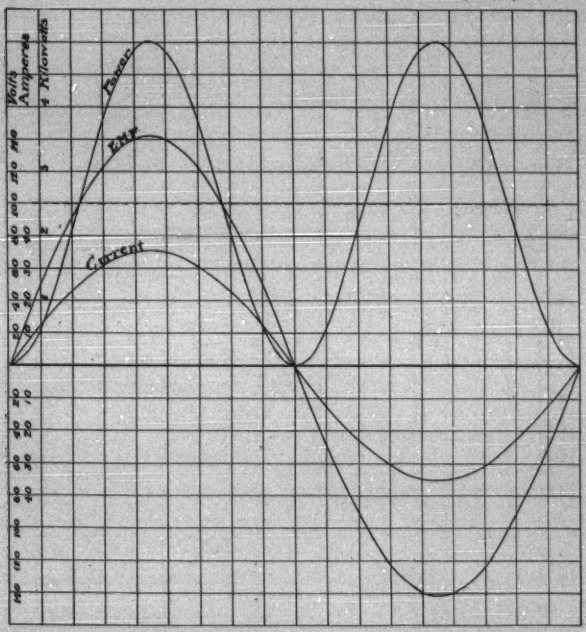


Fig 1—Sinusoidal electromotive force and current curves in phase, and the resultant power curve.

electromotive force and current curves and has only positive values. The physical meaning of this is that at every instant the generator delivers electrical energy to the circuit and this energy is consumed by the circuit. The average height of the power curve is the average power in watts and is in this case equal to the product of the effective volts and amperes.

If the sinusoidal electromotive force and current are in

quadrature the phase difference θ is 90°, and cos θ is equal to zero, so that the average power delivered to the circuit is zero. The curves for this case are represented in Fig. 2.

It is seen that the power curve is again a sinusoid having twice the frequency of the electromotive force or current curves, but that its axis now coincides with the electromotive force and current axis, so that there are alternately positive and negative power loops of equal area. The physical mean-

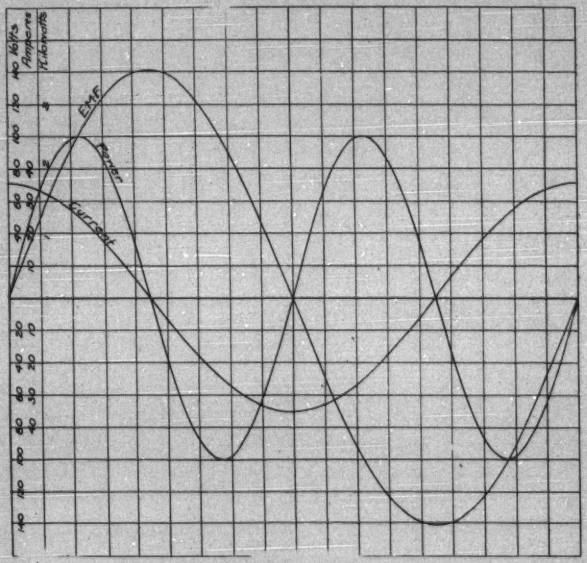


Fig. 2—Sinusoidal electromotive force and current curves in quadrature, and the resultant power curve.

ing of this is that for that half of each half period during which the electromotive force and current are in the same direction the generator delivers energy to the circuit, and this energy is all stored in the reactance of the circuit, and that during the next half of each half period where electromotive force and current are in opposite directions this stored energy is returned from the circuit to the generator driving it as a motor. The

average height of the power curve is the average power and is in this case equal to zero.

If the sinsuoidal electromotive force and current differ θ degrees (always less than 90°) in phase, the curves for electromotive force, current and power take the form shown in Fig. 3.

The power curve is again a sinusoid of double frequency, but

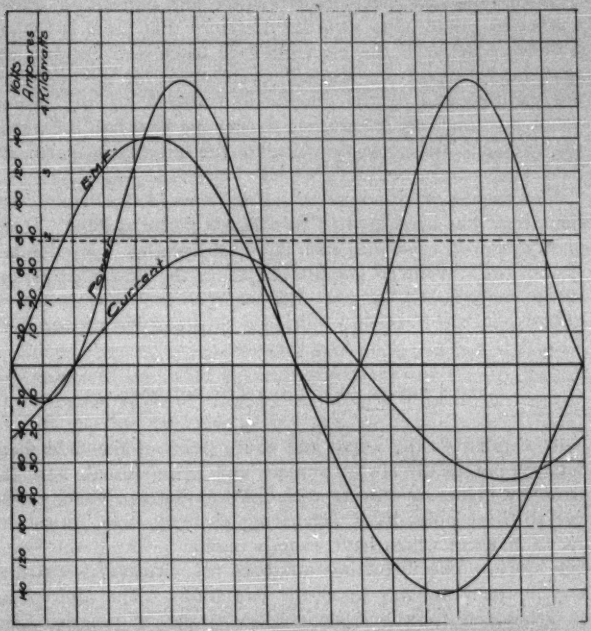


Fig. 3—Sinusoidal current lagging behind a sinusoidal electromotive force, and the resultant power curve.

the positive area is now greater than the negative area. The physical meaning of this is that during the (greater) part of the half period where current and electromotive force are in the same direction, the generator delivers energy to the circuit and part of this energy is consumed by the circuit, and a second part is stored in the reactance of the circuit; during the (less) part of the half cycle where current and electromotive force are

opposite in direction this stored energy is returned from the circuit to the generator driving it as a motor. The average height of the power curve is the average power in watts, and is in this case equal to the product of the effective volts, the effective amperes, and the cosine of the angle of phase difference between electromotive force and current.

With sinusoidal electromotive force and current, a Power Factor less than unity signifies therefore that there is a phase difference between the electromotive force and current, and that during a part of each half cycle some of the electrical energy delivered by the generator is stored in the circuit, which portion is again returned during the next half cycle from the circuit to the generator, driving the latter as a motor and delivering energy to the fly wheel.

This discussion of power pulsation between the dynamo and the circuit has been applied to a single phase system. It applies, however, equally to each one of the phases of a polyphase system; in a balanced polyphase system the power pulsations of the individual phases overlap so that there is always resultant generator action requiring a constant driving torque.

WAVE FORMS WHICH ARE NOT SINUSOIDAL.

In alternators the north and south poles of the field magnets are practically always similar and symmetrical, and the armature inductors moving with uniform angular velocity relative to these poles have alternating electromotive forces induced in them which have exactly similar positive and negative loops. The distorting influence of circuits also always acts in the same way upon the two loops. The alternating electromotive force and current waves met in practice have therefore practically always exactly similar positive and negative loops.

It has been shown by Fourier that any periodic wave can be resolved into or made up of a fundamental sine wave and a series of harmonics. When a periodic wave has its positive and negative loops similar, it can only contain odd harmonics, because the effect of even harmonics is to change the form of the negative from the positive loops. The general expression

for any electromotive force wave can therefore be written as a series with only odd harmonics, giving the expression,

$$e = \Sigma\, e_n \sin n\,(\omega\, t - a_n) \qquad (4)$$

$$= e_1 \sin(\omega\, t - a_1) + e_3 \sin 3\,(\omega\, t - a_3) + e_5 \sin 5\,(\omega\, t - a_5) + \text{etc.} \qquad (5)$$

in which

e = instantaneous value of electromotive force.

e_1 = maximum value or amplitude of the fundamental wave.

e_n = maximum value or amplitude of the n^{th} harmonic.

a_n = phase position of e_n expressed in degrees of the fundamental wave.

In the same way we have for the general expression of any alternating current wave

$$i = \Sigma\, i_n \sin n\,(\omega\, t - b_n) \qquad (6)$$

$$= i_1 \sin(\omega\, t - b_1) + i_3 \sin 3\,(\omega\, t - b_3) + i_5 \sin 5\,(\omega\, t - b_5) + \text{etc.} \qquad (7)$$

in which i_n is the amplitude of the n^{th} harmonic, and b_n the phase position of i_n.

Alternating current voltmeters and ammeters indicate effective values of irregular electromotive force or current waves. The effective value of an irregular wave is equal to the square root of one half the sum of the squares of the amplitudes of its harmonic components. In symbols,

$$I = \sqrt{\frac{i_1^2 + i_3^2 + i_5^2 + \text{etc.}}{2}} \qquad (8)$$

similarly

$$E = \sqrt{\frac{e_1^2 + e_3^2 + e_5^2 + \text{etc.}}{2}} \qquad (9)$$

Substituting for the amplitudes the corresponding effective values of the harmonic components by means of equation (2) we obtain

$$I = \sqrt{I_1^2 + I_3^2 + I_5^2 + \text{etc.}} \qquad (10)$$

and

$$E = \sqrt{E_1^2 + E_3^2 + E_5^2 + \text{etc.}} \qquad (11)$$

The power developed by an irregular electromotive force and current wave is equal to the average of the instantaneous

products of volts and amperes, and this average product would be indicated on a wattmeter suitably connected in the circuit.

Since the average product of any two harmonic waves of different frequencies is equal to zero when taken over a complete cycle of the lower frequency, it follows that only harmonic components of electromotive force and current of the same frequency can produce resultant power. The resultant power of irregular electromotive force and current waves is therefore equal to the sum of the products of the effective values of the synchronous harmonic electromotive force and current components and the cosines of their respective angles of phase difference. In symbols

$$p = E_1 I_1 \cos \theta_1 + E_3 I_3 \cos 3\ \theta_3 + E_5 I_5 \cos 5\ \theta_5 + \text{etc.} \qquad (12)$$

in which $\theta_n = (a_n - b_n)$, that is the angle of phase difference between e_n and i_n expressed in degrees of the fundamental wave. Equation (12) may be written in terms of the amplitudes of the harmonics of electromotive force and current, so that

$$p = \frac{e_1 i_1}{2} \cos \theta_1 + \frac{e_3 i_3}{2} \cos 3\ \theta_3 + \frac{e_5 i_5}{2} \cos 5\ \theta_5 + \text{etc.} \qquad (13)$$

Since Power Factor is by definition, the ratio of true watts to apparent watts, we can write the general equation for Power Factor from equations (5), (7) and (13)

$$\text{P. F.} = \frac{\frac{1}{2}(e_1 i_1 \cos \theta_1 + e_3 i_3 \cos 3\ \theta_3 + e_5 i_5 \cos 5\ \theta_5 + \text{etc.})}{\frac{1}{2}\sqrt{(e_1^2 + e_3^2 + e_5^2 + \text{etc.})\,(i_1^2 + i_3^2 + i_5^2 + \text{etc.})}} \qquad (14)$$

and in effective values

$$\text{P. F.} = \frac{(E_1 I_1 \cos \theta_1 + E_3 I_3 \cos 3\ \theta_3 + E_5 I_5 \cos 5\ \theta_5 + \text{etc.})}{\sqrt{(E_1^2 + E_3^2 + E_5^2 + \text{etc})\,(I_1^2 + I_3^2 + I_5^2 + \text{etc.})}} \qquad (15)$$

These are the most general expressions for Power Factor, and show that with irregular electromotive force and current waves the Power Factor is a function of the amplitudes and phase positions of the harmonic components of the electromotive force and current waves. It can be shown mathematically that the numerator of equation (14) can never be greater than the

denominator, from which it follows that Power Factor can never have a greater value than unity.

Since the maximum value of a cosine is unity it follows that for $\cos \theta_n = 1$, equations (14) adn (15) will be a maximum; this means that the Power Factor is a maximum when the synchronous harmonic components of electromotive force and current are in phase. Equations (14) and (15) for Power Factor then simplify to

$$\text{P. F.} = \frac{e_1 i_1 + e_3 i_3 + e_5 i_5 + \text{etc.}}{\sqrt{(e^2_1 + e^2_3 + e^2_5 + \text{etc.})\,(i^2_1 + i^2_3 + i^2_5 + \text{etc.})}} \quad (16)$$

and

$$\text{P. F.} = \frac{E_1 I_1 + E_3 I_3 + E_5 I_5 + \text{etc.}}{\sqrt{(E^2_1 + E^2_3 + E^2_5 + \text{etc.})\,(I^2_1 + I^2_3 + I^2_5 + \text{etc.})}} \quad (17)$$

When an irregular electromotive force wave is applied to a circuit with constant resistance and zero reactance an irregular current wave is produced whose instantaneous values are in a constant ratio with the contemporaneous values of the electromotive force. This current wave contains the same harmonic components as the electromotive force wave; and these components are in phase with and in a constant ratio with the corresponding harmonic components of the electromotive force wave; this constant ratio is expressed by

$$\frac{E_1}{I_1} = \frac{E_3}{I_3} = \frac{E_5}{I_5} = \text{etc.} = R \text{ (constant)} \quad (18)$$

which is evidently the resistance of the circuit.

From (18)

$$E_1 = RI_1, E_3, = RI_3, E_5 = RI_5 \text{ etc.}$$

which substituted in (17) gives

$$\text{P. F.} = \frac{R\,(I^2_1 + I^2_3 + I^2_5 + \text{etc.})}{\sqrt{R^2\,(I^2_1 + I^2_3 + I^2_5 + \text{etc.})\,(I^2_1 + I^2_3 + I^2_5 + \text{etc.})}} \quad (19)$$
$$= 1$$

The Power Factor of a circuit with constant resistance and zero reactance is therefore unity no matter how irregular the applied electromotive force wave may be. An exception to this would be the case of a circuit containing a counter elec-

tromotive force from a separative source, in which the Power Factor would in general be less than unity.

Another way to state this result is to say that with an irregular electromotive force and current wave the Power Factor can only be unity if the instantaneous values of electromotive force and current are in a constant ratio, that is, if the same harmonics are present in both waves and are in phase and have their amplitudes in a constant ratio.

Irregular electromotive f orce and current waves having different harmonics or having synchronous harmonics whose amplitudes are not in a constant ratio produce a Power Factor less than unity, the value of which may be calculated by means of equations (14) or (15).

A common example of irregular waves is furnished by the electric arc, in which the current is distorted because the resistance of the arc is not constant but is a function of the current. *Curves of electromotive force, current and power, for a mineralized carbon open arc, are shown in Fig. 4. The potential differences are taken across the arc.

It will be noticed that the electromotive force and current curves cross the time axis at the same point and may in this sense be said to be in phase, and the power curve has only positive values. The Power Factor for this arc is 0.85. The lowering of the Power Factor is due to the presence of harmonic components in the current or electromotive force wave for which there are no synchronous harmonic components in the other, and may also be due to phase difference between synchronous harmonic components of electromotive force and current.

In practice it frequently happens that the electromotive force curve is sinusoidal and the current which it produces is distorted. The expression for power is for this case obtained from equation (12) by making E_3, E_5, etc., equal to zero, giving,

$$p = E_1 I_1 \cos \theta_1 \qquad (20)$$

which shows that only the fundamental of the current curve

*The curves of electromotive force and current are copied from an oscillogram, given by A. Blondel in a paper before the International Electrical Congress in 1904.

produces real power, while the upper harmonic components of the current curve produce wattless power. The expression for Power Factor for this case is similarly obtained from equation (14), giving

$$\text{P. F.} = \frac{E_1 I_1 \cos \theta_1}{\sqrt{E^2_1 (I^2_1 + I^2_3 + I^2_5 + \text{etc.})}} \qquad (21)$$

which simplifies to

$$\text{P. F.} = \frac{I_1}{I} \cos \theta_1 \qquad (22)$$

Equation (22) shows that distortion of the current with sinusoidal electromotive force has the effect of lowering the Power Factor.

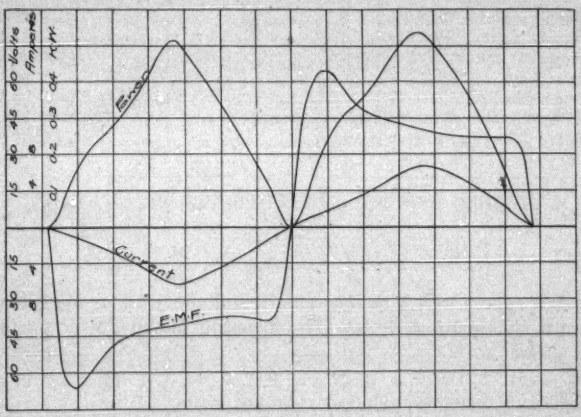


Fig. 4—Curves of potential difference, current and power for an open arc with mineralized carbons

A practical example of a sinusoidal electromotive force and distorted current is illustrated in Fig. 5.

The values of electromotive force and current for these curves were obtained by experiment* from the supply circuit

*The data for the mercury vapor rectifier are taken from experiments made in the Department of Electrical Engineering of Stevens Institute by

of a single phase Cooper Hewitt mercury vapor rectifier operating on a 60 cycle supply circuit and charging a battery of storage cells. The electromotive force curve is sinusoidal except for a slight distortion near the zero points which is due to armature reactance; this difference from a sinusoidal wave is neglected. The current curve is considerably distorted, due mainly to the shifting of the vapor stream from one anode to the other near the zero points of the supply electromotive force and to the action of the sustaining coil. The fundamental of the current wave has been found by analysis and is shown in the diagram. The following values were found for these curves:

Supply voltage, effective	$E =$ 102.9
Supply current, effective	$I =$ 11.5
Apparent watts	$EI =$ 1183
True watts	$p =$ 1100
Power Factor	$p \div EI =$ 0.93
Effective value of fundamental of current	$I_1 =$ 11.4
Phase difference between E and I_1	$\theta_1 = 20°$
Cos θ_1	= 0.94

Calculating the Power Factor from equation (22) we get

$$\text{P. F.} = \frac{I_1}{I} \cos. \theta_1 = \frac{11.4}{11.5} \times 0.94 = 0.931$$

which agrees well with the value found above by dividing true watts by apparent watts. The lowering of the Power Factor

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Messrs. L. A. Hazeltine, G. Crisson, P. J. Howe, A. F. Ernst and E. F. English, in connection with their graduating theses.

A convenient graphical method for analyzing irregular waves was devised by Mr. L. A. Hazeltine while working on his thesis. This method was also applied to finding effective values and average power. A description of the method is given in the October, 1906, issue of the *Stevens Institute Indicator*.

The effective values of current and electromotive force obtained from the a.c. instruments (hot wire and dynamometer types) in some cases did not agree with the values calculated from the waves. The discrepancies were probably due to errors in the instruments, due possibly in some cases to the peculiar wave shapes. The values calculated from the waves were used in the calculations. The readings of the d.c. instruments (Weston type) and of the wattmeters (Weston type) generally agreed well with the corresponding values calculated from the waves.

from 0.94 to 0.93 is therefore due to distortion of the current wave.

If the fundamental of the current wave is in phase with the electromotive force, equation (22) for Power Factor becomes

$$\text{P. F.} = \frac{I_1}{I} \qquad (23)$$

and is therefore less than unity, and equal to the ratio of the

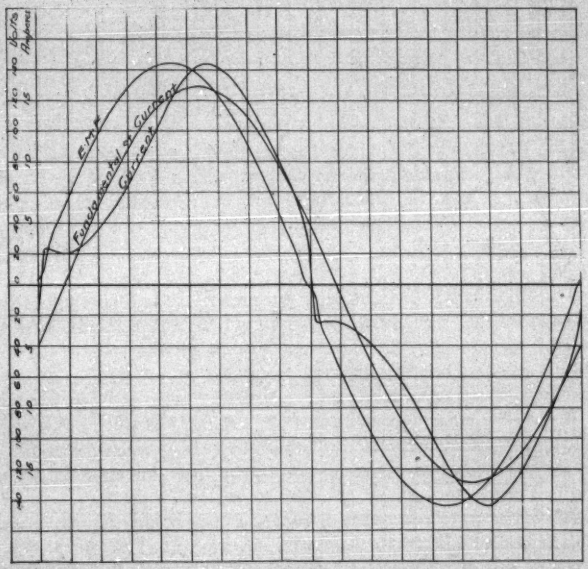


Fig. 5—Curves of electromotive force and current from the supply circuit of a Cooper Hewitt mercury vapor rectifier with storage battery load and also the fundamental of the current wave.

effective value of the fundamental wave to the effective value of the distorted wave. The harmonics in the current wave produce zero resultant power with the electromotive force wave.

An example of an harmonic electromotive force and distorted current in phase is given in Fig. 6. The values are assumed for illustration and have not been obtained by experiment.

The effective value of the electromotive force is 100 volts. The distorted current is made up of a fundamental $I_1 = 25$ amperes (effective) and a third harmonic $I_3 = 10$ amperes (effective), both being in phase with the electromotive force. The effective value of the actual current is therefore $I = \sqrt{25^2 + 10^2} = 26.92$ amperes. The apparent power is $I \times E$

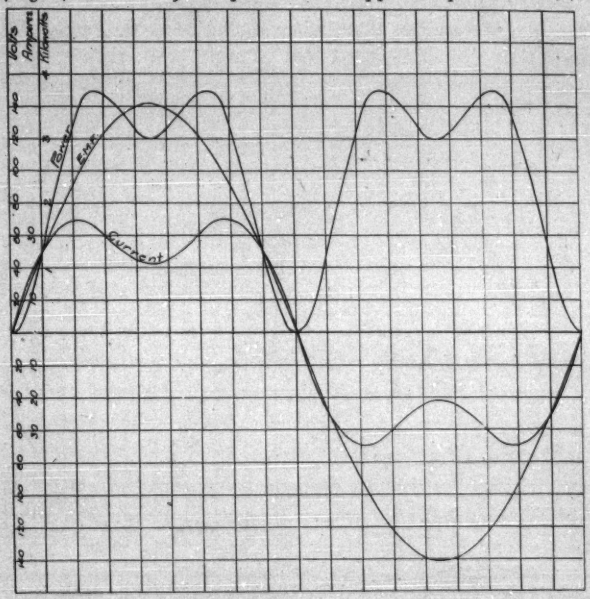


Fig. 6.—Sinusoidal electromotive force and distorted current consisting of a fundamental and the third harmonic in phase with the electromotive force, and the resultant power curve.

$= 2692$ watts. The true power is $I_1 \times E = 2500$ watts. The Power Factor is therefore $2500 \div 2692 = 0.93$. The Power Factor can also be calculated from I_1 and I by means of equation (22), giving

$$\text{P.F.} = I_1 \div I = 25 \div 26.92 = 0.93$$

as found before. The lowering of the Power Factor from 1 to 0.93 is in this case entirely due to distortion of the current

curve. If the phase position of this third harmonic were shifted and combined with the same fundamental sine wave of current the resultant distorted current curve would have a very different shape and would cross the time axis at a different point from the crossing of the electromotive force curve. The average power and the Power Factor would however remain the same as before.

PULSATING CONTINUOUS CURRENTS.

The continuous currents obtained from alternating currents by means of rectifiers are not of constant value but are pulsating; a single phase rectifier produces generally considerable pulsations in the rectified current, while two and three phase rectifiers produce a more nearly constant current. A pulsating current is equivalent to a continuous current of constant value and a superimposed alternating current. The laws of alternating currents must therefore be applied to pulsating currents. A direct current ammeter or voltmeter of a type which does not respond to alternating currents will indicate the average or mean value of a pulsating current or electromotive force; an alternating current ammeter or voltmeter of a type which is correct also on direct current will indicate the effective value of a pulsating wave. The effective value of a pulsating wave is always greater than the average value.

If the pulsating electromotive force and current are measured in a circuit with constant resistance and zero reactance and zero counter electromotive force the product of the effective volts and amperes is the true average power in watts. This case is similar to the one discussed in connection with equation (19) in the first part of this paper.

If the pulsating electromotive force and current are measured in a circuit containing reactance, or a constant counter electromotive force such as a charging storage battery, or a resistance which is a function of the current, such as arc lamps, the product of the effective volts and amperes gives the apparent watts, which, however, is greater than the true watts; the true watts must be measured with a wattmeter. The true watts divided by the apparent watts is the Power Factor. It

is therefore seen that a circuit with a pulsating continuous current may have a Power Factor less than unity.

An example of a pulsating electromotive force and current is illustrated in Fig. 7, in which the curves represent the rectified current from a single phase mercury vapor rectifier, charging a battery of storage cells and having also a regulating rheostat in series. The values of electromotive force and cur-

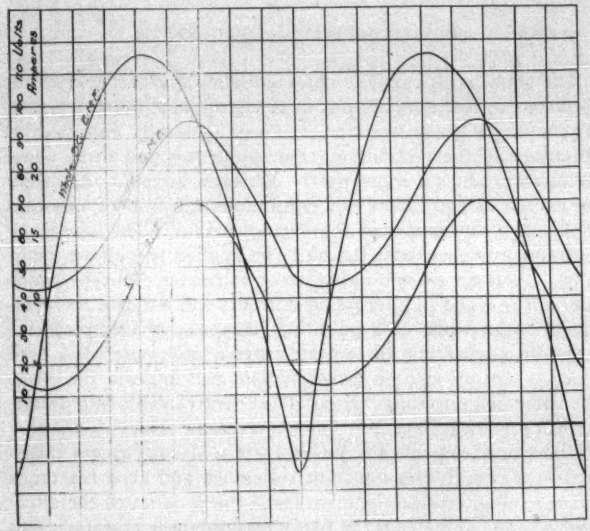


Fig. 7—Curves of electromotive force and current from the rectified current circuit of a single phase mercury vapor rectifier charging a battery of storage cells.

rent were obtained by experiment and correspond to the curves of supply electromotive force and current shown in Fig. 5 for the same rectifier. One of the electromotive force curves represents the potential difference across the storage battery and rheostat, or load, and the other the potential difference across the load and the sustaining coil, or the entire d.c. circuit. The following are the values for the circuit of the rectified current:

Average p.d. across total d.c. circuit	$= 68.7$
Effective p.d. " " " "	$E_2 = 80.3$
Average current	$i_{aver.} = 9.9$
Effective current	$I = 11.1$
Apparent watts, total d.c. circuit	$E_2 I = 891$
True watts " " "	$p_2 = 800$
Power Factor of " " "	$p_2 : E_2 I = 0.898$
Average p.d. across load	$= 67.9$
Effective p.d. across load	$E_1 = 69.8$
Apparent watts in load	$E_1 I = 775$
True watts in load	$p_1 = 759$
Power Factor of load	$p_1 : E_1 I = 0.98$

It should be stated that the resistance loss in the battery and rheostat was in this test greater than the useful energy stored in the battery.

The Power Factor of the entire d.c. circuit is seen to be considerably less than unity, on account of the effects of the sustaining coil and of the constant counter electromotive force of the battery in altering the shapes of the waves. That is, the instantaneous values of the electromotive force and current are not in a constant ratio as required for unity Power Factor. (See equation (19)). The Power Factor of the load is also less than unity for the same reason. This Power Factor would have been lower if the resistance loss had been a smaller part of the load.

It will be noticed that the average values of the pulsating electromotive force and current, as indicated on direct current instruments, are considerably less than the corresponding effective values, as indicated on the alternating current instruments. The product of the average volts and amperes is therefore not the average power. The reason for this lies in the mathematical fact that the average product of two sets of numbers is not equal to the product of their average values. In a circuit with pulsating current the average power should therefore be measured by means of a wattmeter.

In the case of a storage battery charging with a pulsating current, the average current as indicated on a d.c. ammeter is the true charging current, and this average current multiplied by the time, gives the ampere-hours of charging, and this ampere-hours multiplied by the constant counter electromotive

force of the battery gives the watt-hours which is stored as chemical energy in the battery.

RESUMÉ.

Power Factor, as defined by the ratio of true to apparent watts, is in general less than unity, and can never have a value greater than unity.

In circuits with distorted alternating electromotive force and current waves the Power Factor is determined by two components, first, the angles of phase difference between synchronous harmonic components of electromotive force and current (as determined from Fourier's series), and, secondly, by the variation from proportionality of the harmonic components of the waves. The component of Power Factor which is due to phase difference has the physical significance that there is a corresponding surging of energy between the dynamo and the circuit. The other component, due to the variation from proportionality of the waves, represents an apparent surging of energy but has no real physical significance, and is in other words due to the mathematical fact that the average of the products of the instantaneous values of two waves is in general less than the product of their effective values.

With irregular wave shapes the phase position is sometimes measured from the zero points of the waves and sometimes from the maximum points; the latter has the disadvantage that the maximum point is not well defined and that some waves have more than one maximum point. The author has preferred therefore to use the zero points from which to measure phase position.

It should be noted that the phase difference between irregular waves of alternating current and electromotive force, as measured between their zero points, does not bear a direct relation either to the power or to the Power Factor of the circuit. It has been shown that two irregular waves may be in phase, that is cross the time axis at the same points, and yet have a low Power Factor. Similarly two irregular waves may be considerably out of phase, that is cross the time axis at different points some distance apart, and yet the Power Factor may be greater than the cosine of this angle of phase difference

between the irregular waves. The reason for this lies in the fact that certain harmonics alter the wave shapes near the zero points of the irregular waves so that these zero points of the irregular waves are shifted considerably from the zero points of their fundamental sine components, and the latter are generally the principal elements which determine the power and Power Factor. The ordinary alternating current arc is a good example of distorted electromotive force and current in phase, and yet having a low Power Factor.

In the special case of a sinusoidal electromotive force and distorted current, which is of frequent occurrence in practice, the Power Factor is the product of two factors (equation (22)), one factor being the cosine of the angle of phase difference between the fundamental sine wave of current (as determined from Fourier's series) and the electromotive force, and the second factor being the ratio of the effective value of this fundamental sine wave of current to the effective value of the distorted current wave.

The supply circuit of a mercury vapor rectifier is a good example of distorted current produced with sinusoidal electromotive force. In the example given this distorted current was very nearly in phase with the electromotive force, but the Power Factor was 0.93. It was shown that the fundamental sine component of the distorted current was considerably out of phase with the electromotive force, due to the harmonics in the current, and the lowering of the Power Factor was principally due to the phase difference between this fundamental sine component and the electromotive force.

If the Power Factor of a circuit is low on account of phase difference between current and electromotive force it is possible to raise the Power Factor to unity by connecting a suitable reactance or a synchronous machine in shunt with the circuit. If the Power Factor is low on account of wave distortion it cannot be raised by shunted reactance. If the Power Factor of a circuit is low both on account of phase difference and of wave distortion it can only be corrected by shunted reactance for that part which is due to phase difference. In most practical cases wave distortion does not produce serious lowering of Power Factor. Certain kinds of apparatus, such as rectifiers and alternating current arc lamps, produce con-

siderable distortion of the current waves and such apparatus may have inherently a poor Power Factor.

The author's thanks are due to Mr. G. Crisson, Assistant in the Department of Electrical Engineering of Stevens Institute, for help in analyzing waves, and for valuable suggestions, and also to Mr. Percy H. Thomas, of the Cooper Hewitt Electric Co., for valuable suggestions.

THE NEED FOR CORUNDUM.

Never in the history of the abrasive industry has the time been more opportune for the development of corundum properties than at present when there is a scarcity of emery ore.

During 1905, the production of corundum and emery in the United States, according to Mr. Joseph Hyde Pratt, who has written a report on the production of abrasive materials for the United States Geological Survey, amounted to 2126 short tons, valued at $61,464, as compared with 1916 short tons, valued at $56,985 in 1904, an increase of 210 tons in quantity and of $4,479 in value. The corundum mined was from North Carolina and Montana and the emery from New York and Massachusetts.

The Greek and Turkish deposits are not furnishing the grade of emery that is desired, nor the quantity, and this has also been true during the past year of the emery mines in this country. The Canadian corundum deposits supply to some extent the demand for corundum, but there is still a large enough market to warrant the working of deposits in this country.

The importation of corundum and emery into the United States is still largely in excess of the home production. In 1905 these imports were valued at $347,425 against $260,424, the value in 1904.

SOFT GRAPHITE MADE ELECTRICALLY.

Edward G. Acheson, of Niagara Falls, N. Y., has announced that he has discovered a process for making unctuous or soft graphite. Heretofore, the graphite made by the International Acheson Company has been hard graphite, and has been applied to a field not entered by the natural graphites, such as in the manufacture of electrodes, as a battery filler, and as a paint pigment. The soft graphite will be used as a lubricant, as a stove polish and also for coating gunpowder, which is tumbled in graphite to coat or face it. It will also be used for electrotyping.

As it can be manufactured at comparatively low cost, it is expected that the new, soft graphite will become a successful competitor of natural graphite. The product of the experimental furnaces has been very satisfactory as to uniformity. Mr. Acheson predicts that within a few years the manufacture of artificial graphite will be the largest industry at Niagara Falls.—*Eng. and Min. Jour.*

Mining and Metallurgical Section.

(*Stated Meeting, held Thursday, October 18, 1906.*)

Acoma: the Cliff City of New Mexico.*

By Prof. Oscar C. S. Carter.

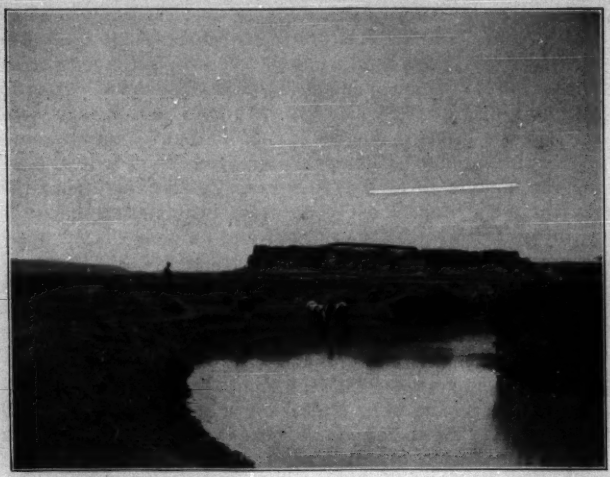
One of the strangest corners of our country and one of the greatest wonders of the Southwest is Acoma, the Cliff City, built centuries before Columbus' time and to-day occupied by the Pueblo Indians, who are the descendants of those conquered by Coronado's expedition 366 years ago. It is the oldest city in the United States and has been inhabited continuously for centuries. Man in every country on the globe is undoubtedly influenced by his environments; this statement holds true with the Indian, African and Mongolian alike, and to a less degree perhaps with civilized man. The conceptions of the Indian by the English and Spaniards were totally different. The cavaliers who sailed up the broad estuaries of the Delaware and Chesapeake and the Puritains who landed on New England's inhospitable shore met a more or less migratory race of Indians who subsisted by hunting and fishing. Many of them were born warriors. The same may be said of the former Indians of the plains who were migratory and warlike. The buffalo was their food supply, and when the white man, with little foresight and less sense, almost exterminated this animal, the food supply of the Indian was destroyed; starvation stared him in the face, and the Government has been obliged to give him an allowance of flour and meat ever since at his new home on the Indian reservation. How different was the experience of the Spaniards who came from Mexico in 1540 with Coronado's expedition in search of the seven cities

*Read by title.

of Cibola? In their conquering march through the Southwest they met a peaceful and agricultural race of Indians, the Zunis, Acomas and Hopis, who were not migratory and were not hunters, but lived in permanent houses of stone on the mesas and in the canons hundreds of years before the discovery of America. In the valleys and at the base of the mesas they raised melons, pumpkins and corn. They are the Pueblo Indians of to-day. They were not hunters, because in the arid and desert district of the Southwest, where they live, there is little to hunt. They were forced to be agriculturists, notwithstanding a harsh environment and deficient rainfall of but ten or twelve inches per year. The Government did not take their land because nobody wanted it. It is not worth having. So they have remained unmolested for centuries in their isolated desert homes. They were not born warriors, although they defended themselves strenuously and often successfully in their impregnable homes against the terrible Apaches and the warlike Navajos, who were migratory. Farther south, near the Mexican boundary line, the Papagos have a still harsher environment, and even less rainfall, and they are reduced to the extremity of living on mesquite beans, seeds and the pulp of the giant cactus, Suguarro. The first spring shower finds them planting a little corn which often fails to reach maturity. The Pai Utes, near Death Valley, California, do not scorn a meal of lizards and snakes. Man's environment influences his whole life, and the proper way to study man is as influenced by his environment. Acoma is located about three miles south of the enchanted mesa, near the southeast boundary of the plateau country, which was described in the previous article on the Enchanted Mesa by the author. It is in the Pueblo region. The ancient Pueblo region, according to Cosmos Mindeleff (19th Annual Report, Bureau Ethnology, Part II,) "extends from Great Salt Lake to beyond the southern boundary of the United States, and from the Grand Canyon of the Colorado River to the vegas or plains east of the Rio Grande and the Pecos. Within this area of about 150,000 square miles ruins can be numbered almost by the thousands." In other words, the present Pueblo Indians and their ancestors, the so-called Cliff Dwellers, dwelt in Utah, Arizona, New Mexico and Southwest Colorado. They occupied all of the plateau region and the

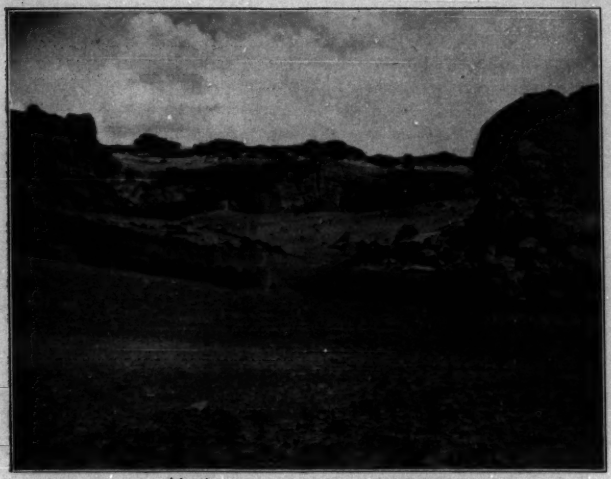
country to the south of it, extending over the boundary line into Mexico. Mindeleff states (13th Annual Report, Bureau of Ethnology, page 258,): Before archeological investigation of the Pueblo region commenced and when there was little knowledge extant by which travelers could check their conclusions, the immense number of ruins in that region was commonly attributed to an immense population, some writers placing the number as high as 500,000. Besides this figure the present population, about 9000, is so insignificant that it is hardly surprising that the ancient and modern villages were separated and attributed to different tribal stocks. It is very doubtful whether the total number of Pueblo Indians ever exceeded 30,000. This is the figure stated by Mr. A. F. Bandelier, whose intimate acquaintance with the eastern part of the Pueblo region gives his opinion great weight. The apparently trifling causes which sometimes result in the abandonment of villages has been alluded to. He reconciles the small population to the thousands of ruins as follows: "Migration among the Pueblo Indians means a slow, gradual movement without any definite end in view. A section of a village moves away from the parent village only a few miles; another section moves to another site. These movements are not possible where outside hostile pressure is great, and if such pressure is long continued, it results in a reaggregation of the various scattered settlements into one large village. Such, in brief, is the process which is termed migration and which has covered the Southwest with thousands of village ruins. As a rule the abandonment of villages was a gradual process, often consuming years. Migration, he says, must not be taken in the sense in which it has been applied to European stocks, a movement of people en masse or in several large groups." The present Pueblo Indians, the descendants of these ancient people, are not migratory. The Pueblo villages of Zuni, Acoma and Oraibe have been inhabited for centuries.

Acoma is thirteen miles south of the Pueblo village of Laguna, which is located along the Atlantic and Pacific R. R., now known as the Atchison R. R. It is also about ninety miles west of Albuquerque. We made the start from Laguna where we secured good accommodations with Mr. Marmon. His son, a graduate of Carlisle, drove us to Acoma. The



Acoma mesa in the distance. Only water in the desert, on the road to Acoma.

Where the trail begins at Acoma sand dunes 80 feet high.



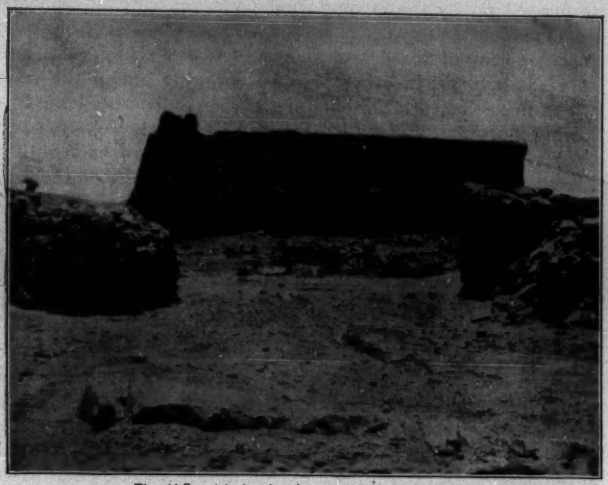
A break or reentrant in the mesa near the corral.

Climbing up the steep trail to Acoma.

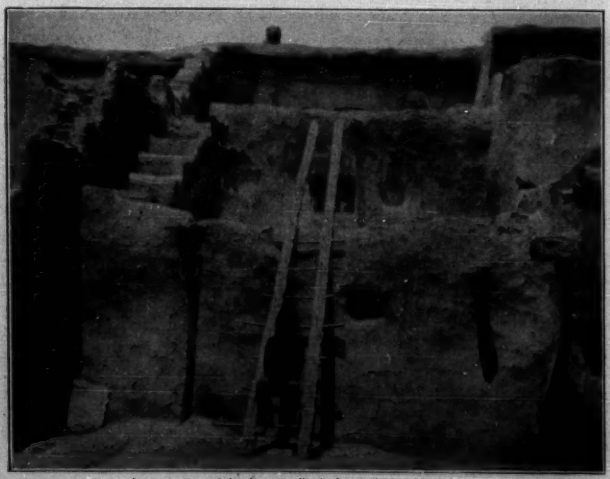
Valley of Acoma and the Enchanted Mesa were described by the author in a previous article. It was rather a hot journey to make in an open wagon across the desert in July. Our water gave out before reaching Acoma and one of our horses, that had evidently been driven hard the day before, fell over from fatigue; the heat and the journey through the deep sand in places were too much for him. Otherwise the journey was uneventful and fairly comfortable. There is but one water hole on the journey to Acoma where water can be obtained for horses; it is not far from the Enchanted Mesa. It is a circular pond about an acre in extent which looks very like a so-called limestone sink, although the surface rock is sandstone. This water is too alkaline for man, but the horses seemed glad to get it. The cattle and what horses and mules the Acoma Indians possess graze on the gramma grass of the valley. This is a common name for several low grasses found in Arizona, New Mexico, Texas and also on the plains east of the Rockies. Mesquite grass and buffalo grass come under this heading. Cattle and sheep are not particular in the West where many of the ranges have been destroyed by putting too many cattle or sheep on a given area. Sheep will even eat sage brush and seemingly thrive on it. The stock near Acoma always frequent this water hole. On the road near Laguna we crossed one of the numerous tributaries of the Rio Grande, which at that point is merely a sluggish alkaline creek, unfit for man or beast. One writer has called this the Rio Puerco River, which is an error, as this river is in Arizona and is a tributary of the Colorado Chiquito, or Little Colorado. We had better say, perhaps, that it is an error for the geographers to correct, as the maps show two rivers of the name Rio Puerco, one in Arizona and the other in New Mexico. The mesa on which Acoma is built rises from 350 to 400 feet above the desert. The walls are generally vertical. The two trails in general use are the horse trail and a trail the Indians use, which stands at an angle of about 50 degrees and in some places is vertical. This is a very trying and steep climb on a hot day. You first climb up some sand dunes, which are from 70 to 80 feet high. One is astonished at these enormous dunes, which seem out of place at the base of this mesa. The sand is formed by the disintegration of the sandstone rock and

is heaped up by the strong wind. On the vertical trail are some ladders, simply cedar posts with rungs, although in some places pieces of wood are wedged between rocky walls and serve as ladders; in other places steps were cut in the rock which necessitated steep climbing. The Indians told the following story to a writer (in American Architect, Vol. 16, page 258): "Several Indians started up the steep trail, each with a live sheep on his back. When they had nearly reached the top, the sheep carried by the foremost man became restless, and the shepherd in his excitement lost not only his hold but also his footing and toppled over, sweeping his companions down on the jagged rocks below where they fell in a lifeless heap. The Indians have carved a representation on the rock near where it occurred, which scarcely serves to steady the nerves."

The trail is steep enough, but we don't want to give the impression it is too bad, because the Indian boys run up and down like squirrels, and my chief concern was the fear of starting a loose boulder down the trail after them. When you reach the flat summit of the mesa you are astonished to find three parallel rows of houses extending for a distance of from 800 to 1000 feet across the mesa. There are two fairly wide streets between the rows. These long unbroken walls of stone and adobe extending across the mesa are divided by partition walls at right angles into separate homes. Imagine a sheer wall of solid masonry on one side of the street and terraced house three stories high, like a series of steps, on the other. These terraces are reached by ladders and the highest roof or terrace is about 35 feet from the ground. The wall of the first row of houses rises sheer from the cliff and is a continuation of its face. This wall faces the north and the terraced part of the houses faces south. It would not be safe for a man giving to sleep-walking to wrap himself in a Navajo blanket and lie down near the wall, because if he should fall it would be a sheer drop of nearly 400 feet. We climbed up the ladder to the terraces and entered one of the rooms. It was clean and smooth like a plastered room. A stocky built, heavy featured Indian was reclining on the floor; a middle-aged, bare-footed Pueblo woman, who was standing near by, grunted welcome. A white-haired, feeble old Indian, who was nearing the century mark, rose slightly from a reclining position and held out



The old Spanish church at Acoma; walls seven feet thick.



A young man of the Acoma tribe in front of his terraced home.

(*Carter*)

A street in Acoma.

Bargaining for a necklace of beads.

his hand in welcome. He was either a former governor or else the cacique, who is the oldest man in the tribe, whose duty it is to treasure in memory's storehouse all the traditions, lore and history of the tribe. He is, in fact, the official historian, and to the young man who is to succeed him he tells everything he knows concerning the history and tradition of the tribe.

They have store rooms and living rooms in which you will find jerked meat, dried peaches, muskmelons and peppers, skins of animals and some silver filagree work and their wearing apparel. The walls and fire-place are adobe and the chimney made of earthenware pots or tinajas from which the bottoms have been removed.

In 1540 Coronado's expedition started in search of the seven cities of Cibola and later saw and conquered Acoma, and the Spanish padres or priests sought to convert the Pueblo people. The Pueblo Indians are a patient people and after years of patient toil they built an adobe church on the summit of the mesa. Every pound of clay was brought up the steep trail from the valley below on the backs of the Indians. The mesa was bare of soil. This was a herculean task when we consider the church is about 150 feet long and 50 to 60 feet high and the adobe walls are said to be from 7 to 10 feet thick. The timbers are 40 feet long and about 1 foot square, and there is no wood of this size nearer than Mt. Taylor, which is 20 miles distant. It was necessary to push these timbers up the trail after they had been carried for miles on the backs of the Indians.

The old church, which was slowly going to ruin and decay, was recently repaired by the Indians, the same year, in fact, that Prof. Libbey scaled the Enchanted Mesa, 1897. One is indeed fortunate to catch a glimpse of the inside of this church with its curious decorations and paintings. A writer in the *Catholic World*, for January, 1873, 16-703, says: "On one side of the altar was a painting of the Virgin and Child, on the other side was a painting of St. Joseph. On the ceiling above the altar were large paintings of the sun and moon, and here we got a chronological glimmer, the last we found. It was an inscription which stated that the church was renovated in 1802. The Indians said it was done by some artist priest who

came from far away, probably Spain or Italy. There are a pair of bells in the belfry. The Acamo tradition is these bells were a gift to the Pueblo from the Queen of Spain. They say they were given some time before the renovation of the church.

"The estufa at Acoma is an underground apartment descended through a trap door, which serves as a chimney. The smoke-begrimed ladder reaches to the bottom. The chamber is 30 feet in length and 15 feet wide and is used as a general place of meeting or public hall or club room. He found four Indians sitting around a fire, each wearing a blanket, the only other covering being a breech clout. It was the duty of these men to watch the fire, that was always kept burning, waiting for the coming of Montezuma. They were finally relieved by others. Francisco, a Pueblo Indian, unlocked a vast trunk of antique form and solidity and took out a pile of manuscript which he handed with solemnity. The first was a missal; the office of the Mass was copied in Latin, in a fair, plain hand, the work of a Spanish missionary. The ink was turned yellow, but the text was clear and legible; but there was no date. It also contained a register, in Spanish, of births and marriages. The earliest record of the Pueblo they found in the trunk was the record of a baptism in 1725. They then put the papers in the chest and locked it with a padlock nearly as large as a traveling satchel. He then sat down to a dinner of chicken stew made intensely hot by chile (red pepper).

"The women wore dark woolen robes made of two pieces about 5 feet long and 3 feet broad, sewed together at one of the narrow ends with an aperture for the head to pass through. The robe is then gathered round the waist and tied with a string. The arms are bare and encircled at the wrist by brass rings. The feet are bare and there is a thick swathing of buckskin to wrap the lower limbs."

The dead at Acoma are buried in a graveyard, but probably there is not another one like this on the continent. The mesa has a bare rocky floor, not an inch of natural soil produced by erosion; so these patient people built a stone wall about 200 feet square and filled it with soil brought with infinite toil from the desert plain below. The soil was brought in baskets or in earthenware vessels. It is stated that at the outer edge

there is a depth of 40 feet of soil. The priests have said that it took 40 years to complete it. Lummis says: "In the graveyard the dead of centuries sleep. The still form is swathed in the costliest blanket and lowered into their narrow bed and upon the earthen coverlet is broken the symbolic jar of water. From the belfry has pealed the last silver clang when they file to the houses where the shamans are blinding the eyes of the ghost that they may not find the trails of the vanished soul upon the four days' journey to Shipaipu. You may see brought forth jars, hand mills, weapons, ornaments and clothing to be broken and rent that they may go with the departed owner."

In an arid region the great desideratum is water, and the Acoma people are extremely fortunate in having a bountiful supply. There is a great natural tank or reservoir, which is really a depression or hollow in the sandstone rock. Here accumulates the water from the melting snows and the summer cloudbursts, for in the plateau region what rain does fall often comes down in torrents accompanied with a most vivid and startling display of lightning and a fearful cannonading. Although evaporation is rapid in this unusually dry atmosphere, still it is a source of perennial supply without which they could never have defied the Navajos and Apaches in their impregnable home. There is also a spring in the base of the mesa and the Acoma women make constant journey to both sources of supply, carrying the water in their earthenware vessels or tinajas securely poised on the head, which doubtless helps to insure an erect and graceful carriage.

On the occasion of our visit to Acoma quite a number of the men were at the summer pueblo, known as Acomita, which is from 12 to 15 miles distant. There is more water at this village and agriculture can be conducted more successfully, because they can irrigate in a small way and raise peaches, melons, beans and peppers. Agriculture cannot be successfully conducted and good crops raised where the rainfall is less than 20 inches a year without irrigation. At Acoma the rainfall is about 12 inches, yet they succeed in filling their storehouses with sufficient food to last them over winter.

At Acoma there is a very interesting estufa or underground chamber. You descend through a trap door and then down

a ladder and you find yourself in a room about 30 feet long and 15 feet wide. This underground room is a council chamber where matters of state are discussed. The Indians, wrapped in blankets, sit around a sacred fire which is never allowed to go out. It is always replenished with fuel. There they await the coming of Montezuma.

In 1598 Juan de Onate conquered Acoma. The Indians wanted him to scale the cliffs and descend into the estufa, but he wisely declined, which was fortunate, as the estufa was full of armed Indians.

The population of Acoma at the present time is between 500 and 600 peaceful Indians who never gave the Government any trouble. They have defended themselves against their enemies, the Navajos and Apaches, in the past. The Apaches, led by Geronimo, have been chased time and again over the border line into Mexico by the United States troops, but the Acoma Indians have been peaceful towards the United States and have never been moved to reservations.

G. W. James states in an article (Scientific American Supplement, Vol. 47-19488,) that Juan de Onate, who conquered Acoma, estimated the population in his epic as 3000, and says when Vincente attacked it the population was 6000 and that only 600 remained after the conflict. The author believes this estimate is entirely too high and greatly exaggerated. As before stated, that eminent authority, Bandelier, states the population of all the Pueblos of the entire Southwest never exceeded 30,000, and the population to-day of all the Pueblo villages is about 9000, so that it is not likely that the population of Acoma at any time in its history ever reached 6000 or that any expedition of the Spaniards ever slew so many. As a matter of fact, one of the most popular and wide-spread errors is the grossly exaggerated statement that the former Indian population of the United States was enormous, some writers' estimates reaching 16,000,000, and that the whites are responsible for their extermination. Major Powell, formerly head of the Bureau of Ethnology, scouts this idea, and Garrick Mallery, of the same Bureau, gives the results of a census taken in 1877, which puts the Indian population of the United States at about 300,000. In many of the tribes a decided increase in population was noticed, and in those tribes in which

a decrease was noticed the cause was sometimes due to absorption by marriage or the ravages of some contagious disease like small-pox. The Indian population of the United States has probably always been small as compared to the vast extent of country over which they roamed. Nevertheless there are reasons why many have the erroneous idea that the former Indian population of the United States numbered millions. The early settlers who sailed up the broad estuaries of the Delaware and Chesapeake and took up their abode on the coastal plain of sands, marls and clay, saw many Indians, because they settled where there was an abundant food supply of ordinary fish and shell fish as well. When, however, the coastal plain was peopled they then settled the Piedmont Plateau, the rocky, rolling country to the westwards, between the coastal plain and the Appalachians; but when the mountains were reached the Indians were not so abundant, and long journeys might be taken and very few met with, the reason being the food supply was not so abundant there. The settlers took home to England exaggerated notions of the total Indian population. Then again, many of the tribes were migratory and changed camps often, which made them seem more abundant to the whites. The Appalachians were just as effectual a barrier to the Indians as to the whites, and our history proves that many of the settlers went south to Georgia where the Appalachians end and came round them to settle on the other side rather than cross them with their belongings. This is not to be wondered at, as the two principal ranges, the Blue Ridge and Allegheny Mountains, are 75 miles apart and were then covered with almost impenetrable forests on account of absence of roads. Then again the French voyageurs and trappers could never have made such long journeys up the Missouri and other rivers and return in safety to civilization if the Indians were as thick as flies. The West is a country of magnificent distances and the present white population has not crowded it as yet and will not for many years to come. There is no doubt that some tribes were almost exterminated by the whites, but as a rule they generally moved to another part of the country or were taken in by another tribe.

The Digger Indians occupied the region roughly between the Sacramento River and the State of Nevada. The Hunting-

ton Expedition, 1899-1903, estimates the present number at from 200 to 250; before association with the whites it is supposed they numbered about 4000. Why they have dwindled down to the present number is a question. They have no tradition of living elsewhere.

Coronado's expedition left Mexico in 1540 in search of gold and the seven cities of Cibola; they traveled through what is now Arizona and New Mexico and it is supposed they came as far east as Kansas. Probably from the Spanish manuscript of Castaneda's narrative most of the information we possess of this intensely interesting expedition is obtained. The following brief account of what part of the expedition thought of Acoma is taken from (the 14th Annual Report of the Bureau of Ethonology, Part I, page 490.) It is a translation of Castaneda's narrative, Chapter 12, of how the people came from Ciyuye to Cibola to see the Christians, and how Hernando de Alvarado went to see the cows: "While they were making these discoveries some Indians came to Cibola from a village which was 70 leagues east of this province, called Ciyuye. Among them was a captain who was called Bigotes (Whiskers) by our men because he wore a long mustache. He was a tall, well-built young fellow with a fine figure. He told the general that they had come in response to the notice which had been given to offer themselves as friends, and that if we wanted to go through their country, they would consider us as their friends. They brought a present of tanned hides and shields and head pieces which were very gladly received, and the general gave them some glass dishes and a number of pearls and little bells, which they prized highly, because these were things they had never seen. They described some cows (buffalos), which from a picture that one of them had painted on his skin, seemed to be cows, although from the hides this did not seem possible, because the hair was woolly and snarled, so that we could not tell what sort of skins they had. The general ordered Hernando de Alvarado to take twenty companions and go with them and gave him a commission for eighty days, after which he should return to give an account of what he had found. Captain Alvarado started on his journey and in five days reached a village which was on a rock called Acuco (Acoma), having a population of about 200 men.

These people were robbers feared by the whole country round about. The village was very strong, because it was up on a rock out of reach, having steep sides in every direction, and so high that it was a very good musket that could throw a ball as high. There was only one entrance, by a stairway built by hand, which began at the top of a slope which is around the foot of the rock. There was a broad stairway for about 200 steps, then a stretch of about 100 narrower steps, and at the top they had to go up about three times as high as a man by means of holes in the rock in which they put the points of their feet, holding on at the same time by their hands. There was a wall of large and small stones at the top which they could roll down without showing themselves, so that no army could possibly be strong enough to capture the village. On the top they had room to sow (?) and store a large amount of corn, and cisterns to collect snow and water. These people came down from the plain ready to fight, and would not listen to any arguments. They drew lines on the ground and determined to prevent our men from crossing these, but when they saw that they would have to fight, they offered to make peace before any harm had been done. They went through their forms of making peace, which is to touch the horses and take their sweat and rub themselves with it, and to make crosses with the fingers of the hands. But to make the most secure peace they put their hands across each other, and they keep this peace inviolably. They made a present of a large number of (turkey) cocks with very big wattles, much bread, tanned deerskins, pine (pinon) nuts, flour (corn meal) and corn."

It is interesting to recall that this quaint account of a visit to Acoma was written about eighty years before the Pilgrims landed on Plymouth Rock.

We who live in Pennsylvania, where the rainfall reaches forty-five inches per year, can scarcely realize how important even a slight rain is in the desert regions of the Southwest; a muddy reservoir means a great deal to the Indians. In the Extra Census Bulletin of the 11th Census it is stated: "A great deal of bad feeling existed between Laguna and Acoma on account of a storage reservoir which they had built together for mutual benefit. Many Laguna families own and hold fields in the Valley of Acoma up to a line separating their

territory from that of their neighbors, which had been agreed upon in years long gone by, and their rights recognized down to the present time; but last summer the people of Acoma denied them water from the reservoir, in consequence of which their corn crops were very poor. Laguna sent a delegation of their principal men to confer with a similar body at Acoma and demand their rights. Acoma claimed that there was not sufficient water for their own use, which statement Laguna denied, charging that Acoma was carelessly or intentionally wasting the water. They came to no settlement. The Governor of Laguna then appealed to the Indian Agent at Santa Fe, who paid no attention to his grievances. Finally, through another source, word was sent impressing upon the agent the urgency of the matter and the necessity of its immediate attention and settlement. He came down and went over to Acoma and was not well received. He went back to Santa Fe and the cornfields of the Lagunians in the Valley of Acoma went dry."

EFFECT OF MOISTURE ON THE STRENGTH AND STIFFNESS OF WOOD.

Very little is definitely known about the influence of moisture on the strength of wood, even by those experienced in handling the material. Since the whole subject is one of great importance, the Forest Service has been making a thorough study of it during the past three years and is about to publish the results of its investigation in an exhaustive technical bulletin entitled, "Effect of Moisture upon the Strength and Stiffness of Wood."

The chief points presented by the study are:

1. The relation of moisture to strength follows a definite law which can be graphically expressed. Proper drying very greatly increases the strength of all kinds of wood, the amount of increase in strength depending upon the species and the dryness. The increased strength given to green wood by thoroughly drying it is so great that it will surprise many. For example, the strength of a piece of unseasoned red spruce may be increased over 400 per cent. by a thorough drying at the temperature of boiling water. Strength decreases again, however, as the wood reassorbs moisture. Air-dried wood, protected from the weather, and containing 12 per cent. of moisture, is from 1.7 to 2.4 times stronger than when green, varying with the species. Stiffness is also increased by drying. These conclusions, however, are drawn from small-sized pieces, not exceeding four by four inches in cross-section, such as are used in vehicle work, tools, etc. Large timbers require years of drying before the moisture is re-

duced to the point where strength begins to increase. It must also be taken into consideration that more or less checking always occurs when large timbers dry; and if this checking is excessive it may cause weakness to counterbalance, partially or entirely, the strength gained in drying. Consequently it is not safe to assume that the average strength of large, so-called seasoned timbers is much greater than that of green or wet ones.

2. The fiber saturation point of a number of species has been determined. This point, which varies with conditions and species of wood, designates the percentage of water which will saturate the fibers of the wood. It has been found that, under normal conditions, wood fiber will absorb a definite amount of moisture; beyond this the water simply fills the pores of the wood like honey in honey-comb. Only that water which permeates the wood fiber has an influence upon the strength. For the following species, the saturation point occurs at the given percentage of moisture based on the dry weight of the wood:

Longleaf pine	25	per cent. Moisture.
Red spruce	31	" "
Chestnut	25	" "
Loblolly pine sapwood	24	" "
Red gum	25	" "
Red fir	23	" "
White ash	20.5	" "
Norway pine	30	" "
Western tamarack	30	" "

3. Prolonged soaking in cold water does not reduce the strength of green wood below that of its fiber saturation point, provided it remains in perfect condition. When wood has been dried and is resoaked, it becomes slightly weaker than when green.

4. Wood soaked in heated water absorbs more moisture because the amount of water which the fiber will contain is increased. This causes a reduction in strength and stiffness, as in wood that is heated or steamed for bending.—(United States Dept. of Agriculture, Forest Service.)

THE RECOVERY OF ARSENIC.

Attempts are now being made to recover the arsenic which goes to waste in the smelter fumes at Anaconda, Mont. This is gratifying, since Mr. C. C. Schnatterbeck points out in a forthcoming report of the United States Geological Survey on the production of arsenic in 1905 that the United States should manufacture all the arsenic and arsenical compounds it may need instead of being obliged to make importations. Arsenic is recovered also from arseno-pyrite mined in Washington and from the ores which occur in Virginia. It is a curious fact that every year several hundred tons of arsenic sulphide obtained in purifying sulphuric acid at chemical manufacturing works are wasted. This object offers an opportunity for profitable research to those whose inventive minds may evolve an economical method of treating this arsenious by-product so that it may become of industrial value.

Mechanical and Engineering Section.

(Stated meeting held Thursday, November 1, 1906.)

Direct Leakage of Steam Through Slide Valves.

By J. V. Stanford,

Assistant Professor in the Mechanical Engineering Dept. Univ. of Penna.

When the weight of steam used in an engine, as determined by condensing the exhaust, is compared with that computed from the indicator card, it is well known that there is considerable difference in the results. This difference between the actual and computed weights, commonly called "the missing quantity," and in some cases amounting to as much as 50 per cent. of the steam used, is generally considered as being accounted for by condensation in the cylinder. The indicator card shows only the actual weight of vapor in the cylinder at a given time, taking no account of the steam which has entered the cylinder and has been condensed by transfer of heat to the cylinder walls. There is no doubt that a large part of the missing quantity may be charged up to cylinder condensation, but there is a possibility that some of it may be due to another cause, namely, valve leakage.

Leakage through the valves of a steam engine may affect the results of an investigation of the engine in various ways. If the steam valves of a Corliss engine leak steam to the cylinder after cut-off, the indicator card should show the expansion line carried above its normal position, and a determination of the steam used, based on the pressure and volume near the end of the stroke, would probably include this leakage. If the exhaust valves leak, however, the expansion line will fall off, and a calculation from the card as before would fail to show the leakage, which would then become part of the missing

quantity. In the case of a slide valve, practically the same thing is true; any leakage from the steam chest to the cylinder will be taken care of by the indicator card, but leakage to the exhaust, either from the cylinder or chest over the bridge, or from the steam chest past the sides of the valve, is not shown by the indicator card, but forms part of the weight shown by the condenser.

The object of this paper is to give the results of some experiments that have been made at the Mechanical Laboratory of the University of Pennsylvania, to determine some facts in connection with leakage of slide valves.

A set of tests was made on a 6″x9″ Sturtevant blower engine, driving a three-quarter housed centrifugal fan keyed direct to the shaft. The engine and fan had been installed in the boiler house of the University to create forced draft, and after a short period of use had stood idle with only an occasional run when used by the students for practice in valve setting. The engine has no governor, depending upon the throttle and the steady resistance of the fan to maintain the proper speed, and the valve is driven direct by the eccentric through a rocker arm.

The valve is of the common D slide valve type, 5 inches wide by $4\frac{3}{4}$ inches long, overlapping the ends of the ports $\frac{1}{4}$-inch on either side. The engine had evidently been designed to work with the cut-off fixed at about .65 of the stroke, and during the tests the valve was set to give this cut-off. With this setting the minimum width of bridge covered by the valve was $\frac{5}{8}$-inch, so that the exhaust port was everywhere protected from direct leakage by contact between the valve and seat at least $\frac{1}{4}$-inch in width.

A balance plate extends between the valve and chest cover to relieve the pressure between the valve and seat, and reduce the resulting friction. The balancing device consists of a cylindrical cup, bearing against a circular boss on the chest cover, and telescoping over a cylindrical projection from the top of the valve, the telescoping joint being made tight by two split rings. Contact is maintained between the balance plate and chest cover by four light springs. Steam leaking through the packing rings to the inside cavity of the balance plate is discharged through two 3/16-inch holes in the top of the valve

direct to the exhaust cavity, so that the pressure over a large part of the valve is exhaust pressure. This leakage is also part of the missing quantity, for it goes to the condenser without affecting the indicator card.

In preparing for the tests, the engine exhaust was piped to a surface condenser, and arrangements made for collecting and weighing the condensation; a pressure gauge was attached to the steam chest and a revolution counter geared to the eccentric strap. Indicator cards were also taken.

Two runs were then made with the engine working normally under the load of the fan, with the balance plate on the valve, and readings were taken to give weight of steam condensed, revolutions per minute, pressure in the steam chest, and the indicated horse power. Average results from the two tests showed that the engine was developing about 5.13 horse-power, and was using about 91.2 pounds of steam per indicated horse-power per hour.

The balance plate was then removed from the valve, the holes through the top of the valve plugged with wood, leaving the valve unbalanced, and tests run as before. These tests gave a steam consumption of 60.5 pounds per indicated horse-power per hour, or 30.7 pounds less than when the balance plate was in place, due to the difference in leakage.

In the first case the leakage was through the balance plate and under the valve; in the second case under the valve only, but the difference was probably due, not so much to leakage through the balance plate, as to the fact that in the first case the valve was only lightly seated, while with the balance plate removed it was seated firmly by the whole pressure of the steam and a good joint maintained with the seat.

In order to determine the actual amount of leakage, the steam ports of the engine were plugged by driving in blocks of dry white pine, filling the steam passages flush with the valve seat. One cylinder head was then removed and the stuffing box opened to relieve any pressure in the cylinder due to leakage through the plugs. The eccentric sheave was loosened on the shaft and bolted to a large wood pulley placed beside it. The pulley was belted to a one horse-power electric motor, geared to drive the pulley and eccentric about the shaft at the same speed as had been used in the previous tests. Having

thus reproduced the conditions of running of the valve as nearly as possible, except that all passage of steam to and from the cylinder was eliminated, it was fair to assume that all the steam now reaching the condenser was due to leakage from the chest to the exhaust and that the amount was practically the same as when the engine was running normally. In running these tests, the motor was started and adjusted to the proper speed, then the trottle valve was opened carefully until the pressure in the chest was the same as in the other tests. Considerable difficulty was experienced in making the wooden plugs in the steam passages hold the pressure, and several were blown through into the cylinder before the experiment succeeded, with no disastrous effect, of course, for the cylinder ends were open, and the piston stationary.

A test under these conditions, with the balance plate on, showed leakage amounting to 43.9% of the total steam consumption of the engine as determined by the first tests; when the balance plate was removed, the leakage was 13.9% of the steam consumption.

In order to verify the assumption previously made that the excessive leakage with the balance plate on was due to imperfect seating of the valve when balanced, tests were run with the balance plate off and with varying pressure in the chest, when it was found that the leakage decreased rapidly as the pressure increased.

As stated before the engine had been standing idle for some time and the valve and seat were not in perfect order, but their condition was not unusually bad, for when tested in the ordinary manner by opening the throttle with the valve standing still over the ports only a trifling leakage was apparent, which makes it appear that the standing test for leakage, so commonly used, is a very poor index of what may take place when the valve is running.

In order to determine the effect of the balance plate in reducing the work required to drive the valve gear, the electric motor driving the eccentric was calibrated for efficiency and wattmeter readings taken, giving data for computing the power absorbed by the eccentric and valve under varying conditions. It was found that the power used with the balance plate on was .25 horse-power, and that it remained practically

constant for varying pressures in the chest. Without the balance plate, the power required increased with the pressure and amounted to .38 horse-power for the pressure previously used. While the saving shown here is slight, the value of the balance plate for much larger valves is unquestioned, and no doubt results in a net saving when the parts are in perfect working condition, but it would seem that in a small engine receiving the ordinary care, its presence may become detrimental in the course of time, owing to its tendency to increase the leakage due to poor contact between the valve and seat.

METALLICS.

A heavy expense in conducting the asphalt business is the price of barrels for containing the product. No cheap substitute has yet been found.

Most of the oil asphaltum made in California is a by-product from the distillation of lubricating and illuminating oils and lighter products from crude petroleum, which has an asphaltic base.

Internal strains in iron and steel are the result of stresses within the mass of the piece, some parts being in tension and some in compression, each part striving to relieve itself from strain and make the piece assume a form in which all parts are at rest.

R. S. Woodward has computed that, assuming the average density of the earth's crust to be 2.75, the density at the center is 10.74, and at 100 miles depth it is 3.03. Owing to the rigidity of the rocks, no increase in density is manifest above a depth of five miles.

Calumet and Hecla copper is particularly free from natural impurities, showing 99.89 per cent. of copper; 0.1 per cent. of oxygen, and 0.01 per cent. of iron and arsenic. Its electric conductivity, when drawn to 0.104-in. diameter, as 99.5 to 100 Mathiesson standard.

Aluminum bronzes containing less than 4 per cent. aluminum are easily worked, but beyond that point the bronze becomes hard to work. Such a bronze can be rolled, but wire cannot be drawn from it. With 6 per cent. and over of aluminum the metal cannot ever be rolled.

Pure gypsum contains 79.1 per cent. of calcium sulphate and 20.9 per cent of water. Deposits of gypsum large enough to be worked for plaster are, however, rarely even approximately as pure as this. Gypsum used for plaster usually carries varying, and often high, percentages of clay, limestone, dolomite, iron oxide, etc.

When alloyed with copper, aluminum acts similarly to zinc, but much more strongly, so that an addition of 1 per cent. aluminum produces as much effect as 3.5 per cent. of zinc. Aluminum bronzes are much stronger than ordinary brasses, but those containing 10 per cent. or more of aluminum are so hard that they cannot be worked.

Portland cement made in the United States is formed from four combinations of materials: Argillaceous limestone and pure limestone; marl and clay; chalk and clay; hard limestone and clay or shale. More than half of the total portland cement of the United States is now made from the first-mentioned pair, but that from the last-mentioned group is rapidly increasing.—*Eng. and Mining Journal.*

COMPARATIVE STRENGTH OF GREEN TAMARACK AND GREEN NORWAY PINE.

A series of tests to determine the relative strength of green tamarack and green Norway pine timber has recently been made by the Forest Service of the United States Department of Agriculture at the timber testing laboratory at Purdue University, Lafayette, Indiana. The material was furnished by the Kettle River Quarries Company of Minneapolis, and nearly all of it grew in St. Louis County, Minnesota. The strength values obtained apply only approximately to timber of the same species grown elsewhere.

Bending tests were made upon beams with a span of thirteen feet six inches and ranging from four by ten to six by twelve inches in cross-sections. From these tests, showing the strength and stiffness of sound green tamarack and Norway pine in structural sizes, the results were as follows:

Strength (Modulus of rupture)	Tamarack	4,600 lbs. per sq. in.
	Norway pine	4,000 " " " "
Stiffness (Modulus of Electricity)	Tamarack	1,240,000 " " " "
	Norway Pine	1,189,000 " " " "

Green tamarack thus appears to be uniformly stronger and stiffer than green Norway pine. When oven-dry tamarack weighs twenty-nine pounds per cubic foot and Norway pine about twenty-four pounds per cubic foot.

Tamarack is usually of slower growth than the pine. Bending tests on small clear pieces indicate that strength decreases in tamarack when the rate of growth is faster than an inch in eight years, and in Norway pine when the growth is faster than an inch in ten years. Comparative tests on the seasoned timber of the two species will be made later.

An alloy of sixty parts copper, one part tin and thirty-nine parts zinc, is found to offer great resistance to the action of sea water, and has been largely used in naval construction.

Section of Photography and Microscopy.

(Stated meeting held Thursday, October 25th, 1906.)

Supplementary Illumination.

By Mr. John Bartlett.

At a recent meeting of one of our learned societies an interesting discussion took place as to the keeping qualities of orthochromatic plates.

The concensus of opinion was that they not only deteriorated by age, but that even proper exposures which remained undeveloped for some time had a tendency to fog when developed, comporting themselves similar to originally overtimed plates.

The important suggestion was made that the substances employed in orthochromatising had the power of absorbing light and so probably continued the action to such an extent as to act injuriously upon the plate.

Of course the truth of such a supposition requires careful investigation, but when we call to mind that the majority of the chemicals used to give color-values, exhibit phosphorescent or fluorescent qualities, there may be some reason for the supposition.

The inertia of the plate must be overcome by the impact of light before it is possible to get a latent image, and so the absorbed light may act as a sort of spur, or in other words, give to the plate an impetus.

We know that even with our extremely rapid plates there is a limit to the speed at which the shutter does act, even under the brightest illumination.

In the days of wet collodion practice the photographer sought to stimulate the speed of the plate by subjecting it for

a brief interval to the influence of light before or after exposure in the camera. It was claimed that this "flashing," as it was called, tended to bring out more detail, the parts of the plate already under the influence of the light, accepting this impetus which the unexposed portions were not able to avail themselves of.

Some went so far as to insert actinic colored glass in the diaphragm of the lens. Others colored the interior of the camera white or blue in the belief the action of light was increased thereby.

Some years ago a method of auxiliary lighting was recommended to increase the sensitiveness of albumen printing-out paper. It was found that if a piece of silvered paper was exposed for a short time to light no apparent visible effect was noticeable, but when an image from a negative was printed on it, the impression, or print, came up much more rapidly at first than it did upon a piece of paper not previously subjected to the "flashing" process. This might go to show that auxiliary lighting sets up an accelerating or continuing action.

This flashing method, we may here remark, was found to be of little practical value to the hurried photographic printer, the spur or impetus lasting only for a brief time, the print on the unexposed paper catching up and progressing along with the other, both finishing at about the same duration of time.

In the course of some recent experiments toward producing a uranium paper, very sensitive to the action of artificial light, I placed a sheet of coated paper (the salt being an axalate of uranium) in a portfolio in contact with an engraving. In less than a day thereafter on opening the book I was surprised to find a beautifully distinct impression of the print. I say "surprised," not because the impression was there, but because the paper had been coated in a very feeble light and therefore could have absorbed but very faint radiations.

The subject of uranium radiations would lead us too far afield, and besides I would hardly venture any opinion just now about a topic with which I am but little acquainted.

But the question of fog in photography does suggest itself. I have often asked myself what is fog? without any oracular response. What is this disturbing element in development which brings down the anathemas of the photographer? May

it not after all be a potency for good, if only controllable like the other potencies of nature? Perhaps a valuable accessory in development.

Shakespeare tells us

"There is a spirit of good in things evil—"

and why not seek for this good eliminating the evil?

Perhaps we are in a foggy mood ourselves just now, but we cannot refrain from complaining, Why has so little been accomplished in what might be called the philosophy of photography? Despite the labors of eminent men of science and the exhaustive manner in which most scientific problems are treated, comparatively little inquiry is made into the rationale of photographic phenomona.

In this age of vigorous scientific research the neglect is hard to be accounted for. Scientific photography is neglected too much in the storm and stress of art culture. Our exhibitions of late years are wholly given up to a particular phase of aesthetic feeling called photographic impressionism. Doubtless excellent in its way and important in its direction, but we cannot help thinking that it would repay the patient investigators after scientific truth to devote some of their energy in the direction of photography. With few exceptions, of late the researches in photography have been rather desultory. It may be necessary to toil all night before the morning yields success; but nothing is denied to well-directed effort.

What do we know about the latent image? What has been done to clear up the conception about solorisation? Doubtless discoveries lie hid which might be brought to light by a careful and systematic course of observation and experiment. It may be that some clue to the mystery of the latent image is envolved in the understanding of the phenomena of fog or solorisation. Experience shows us continually how one phenomena depends upon another, but the inductive method seems to have less favor with photographic investigators than the deductive. A theory is set up and facts made to conform thereto, instead of the general principle being an evolution from the facts. We appreciate the great factor of the imagination in scientific discovery, but the temptation must be constantly avoided of wandering off by devious paths from the

straight and narrow way which leads to truth. The only method, we repeat, is to build up from facts observed; to deliberately assemble all parallel instances we can muster; to experiment, rather than passively observe.

Book Notices.

Emery Grinding Machinery: A text-book of workshop practice in general tool grinding, and the design, construction and application of the machines employed. By R. B. Hodgson, A. M. Inst. Mech. E. (2vo., 180 pages.) London: Charles Griffin & Co,. Ltd. Philadelphia: J. B. Lippincott Co.

The author has intended in this volume to prepare a handbook of workshop practice in the methods and machinery employed for grinding, sharpening and polishing metals by means of the emery wheel. The work is profusely illustrated. W.

Carborundum: Von Francis A. J. Fitz-Gerald. Ins Deutsche übertragen von Pr. Max Huth. Mit 9 Figuren und 3 Tabullen im Text. (8vo., 44 pages). Halle a. S. Verlag von Wilhelm Knapp. 1904. (Price, M, 2.)

This volume constitutes the xiii volume of the admirable series of monographs on Applied Electrochemistry that have been issued for a series of years from this publishing house. The author was for years the superintendent of the Carborundum Co., and his exposition of the subject will be accepted as authoritative. W.

Change Gear Devices: By Oscar E. Perrigo. 8vo., pp. 81. New York. The Locomotive Publishing Co., Ltd. (n. d.)

This work is principally a reprint of a series of articles which appeared originally in the columns of "Machinery," and contains the results of an exhaustive examination of the development of the art of constructing change gears for engine lathes, as represented by the patent literature on the subject. Those who are interested in the subject will doubtless find in it much information of value. W.

Physics: By Charles Riborg Mann, University of Chicago, and George Ransom Twiss, Central High School, Cleveland. (8vo., 453 pages). Chicago: Scott, Foresman & Co. 1905. (Price, $1.25.)

This volume is the joint work of two instructors, one a well-known University professor, and the other a High School teacher, and is arranged for the use of pupils along the lines indicated by their extended experience in teaching. W.

Jahrbuch der Elektrochemie und angewandenten physikalischen Chemie. Berichte über die Fortschritte des Jahres 1904. Harausgegeben von Dr. phil. Heinrich Dannell, Breslau, XI Jahrgang. Halle a. S. Verlag von Wilhelm Knapp. 1906. (Price, M. 25.)

This imposing volume of nearly 1000 pages, large octavo, gives an intelligent summary of all the important contributions to the science of electrochemistry that occurred in the year 1904. Like its predecessors of the same series, it is admirably printed and illustrated.

The volume is compiled with the coöperation of a number of noted experts, and no branch of this important and growing department of electrical science is overlooked. W.

PUBLICATIONS RECEIVED.

U. S. Department of Agriculture, Weather Bureau, Bulletin No. 37. Recent practice in the erection of lightning conductors, prepared under the direction of Willis L. Moore, Chief U. S. Weather Bureau, by Alfred J. Henry, Professor of Meteorology. 20 pages, 8vo. Washington, Gov't Printing Office, 1906.

Sixth Annual Report of the Chief of the Mining Bureau to the Honorable Secretary of the Interior, by H. D. McCaskey, Chief of the Mining Bureau, being for the year ending August 31, 1905. 66 pages, plates, maps, 8vo. Manila, Bureau of Printing.

Michigan State Board of Health. Teachers' Sanitary Bulletin for October, November and December, 1905. Three pamphlets, 8vo. Lansing.

Niles Electric Traveling Cranes, for use in stone yards, freight yards, lumber yards, storage yards. Niles-Bement-Pond Company. 19 pages, illustrations, oblong, 16 mo. New York, 1906.

Publications of the Women's Auxiliary of the Massachusetts Civil Service Reform Association. A primer of the civil service and the merit system, by Elizabeth Luther Cary. 14 pages, 24 mo.

The civil service, merit system, the spoils system, by Edward Cary, Document No. 3. 13 pages, 12 mo. Boston, 1905.

The merit system in municipalities, by Clinton Rogers Woodruff. Document No. 6. 14 pages, 12 mo. Boston, 1905.

Brown and Sharpe Manufacturing Company, catalogue of machinery and tools, 1906. 514 pages, illustrations, 24 mo. Providence, R. I.

U. S. Department of Agriculture, Bureau of Chemistry, Bulletins Nos. 64, 74, 78, 95 and 96. The influence of environment upon the composition of the sugar beet, by Harvey W. Wiley, Chief of the Bureau, with details of the annual experiments and a general summary of the five-year investigation, 1900-1904. 229 pages, illustrations, 8vo. Washington, Gov't Printing Office, 1905.

Le Salon de l'Automobile 2-24 December, 1905. Edition de la Revue Technique. 332 pages, illustrations, folio. Paris, Revue Technique, 1905.

Twenty-second Annual Report of the United States Civil Service Commission for the year ending June 30, 1905. 282 pages, 8vo. Washington, Gov't Printing Office, 1905.

Publications of the Bureau of Government Laboratories, Department of the Interior, Philippine Islands. No. 34, Birds from Mindoro and small adjacent islands. Notes on three rare Luzon birds, by Richard C. McGregor. 31 pages, plates, 8vo.

No. 35, five articles on the plants of the Philippines. 99 pages, 8vo. Manila, Bureau of Printing, 1905.

Practical Perspective. A practical explanation of the only practical perspective (isometric), by Frank Richards, associate editor "American Machinist," and Fred. H. Colvin. 59 pages, illustrations, 8vo. New York, Derry-Collard Co., 1905. Flexible cloth, 50 cents.

Der Ban einer Modernen Lokomotive (nach Angaben der Baldwin Lokomotiv-Werke mit 30 in den text gedruckten Netzätzungen) von Ingenieur Dr. Robert Grinshaw. 34 pages, illustrations, 8vo. Hannover, Author, 1905. Paper, 50 pfennig.

Sections.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—Thirty-ninth stated meeting, held Thursday, October 25th, at 8 o'clock. Dr. Henry Leffmann in the chair. Present, eighteen members and visitors.

The first communication on "The Micro-organisms connected with the transmission of Hydrophobia," was read by Dr. Leffmann.

In the course of his remarks, Dr. Leffmann referred at some length to the literature and the history of the disease commonly known as hydrophobia, and then called attention to a recently published monograph on hydrophobia, by Anna Wessels Williams and May Murray Lowden, giving an account of some highly interesting experimental work done by the authors in the Research Laboratory of the Department of Health, New York City. They confirm the conclusions of Negri, that a specific microbe is the cause of the disease. They find the so-called "Negri" bodies invariably present in cases of the disease, and absent in animals not so afflicted.

The subject was discussed by Dr. Wahl and Dr. Edward Goldsmith.

The second communication entitled "Supplementary Illumination," by Mr. John Bartlett, was, in the author's absence, read by the Secretary. It related chiefly to the causation of what is known as "fog" in the development of photographic plates.

The paper was freely discussed by Dr. Goldsmith, Prof. Edward A. Partridge, Mr. Waldemar Lee, the President and the Secretary. The paper was referred to the Committee on Publications.

Adjourned.

M. I. WILBERT, *Secretary.*

MECHANICAL AND ENGINEERING SECTION.—Stated meeting, held Thursday, November 1st, 1906, 8 P.M.

Mr. James Christie in the chair.

The paper of the evening was read by Mr. J. V. Stanford, Asst. Prof. in the Mechanical Engineering Department of the University of Pennsylvania, on "The Direct Leakage of Steam through Slide Valves."

The paper dealt with the leakage of steam through the slide-valve of a small engine, and gave the results of tests made to determine the power used to operate the valve and the leakage both with the valve balanced and unbalanced.

The paper was discussed by Mr. Hugo Bilgram, Mr. Henry F. Calvin, Mr. James Christie and Mr. John C. Parker.

The meeting passed a vote of thanks to the speaker for his interesting communication and was adjourned.

FRANCIS HEAD, *Secretary.*

SECTION OF PHYSICS AND CHEMISTRY.—Stated meeting, held Thursday, November 15th, 1906. Dr. Wahl in the chair.

Present, twenty members and visitors.

The Chairman introduced Mr. R E. Doolittle, Chief of the Government Food Inspection Laboratory, at New York, who presented a paper on "The Inspection of Imported Food." The speaker gave a detailed account of the methods employed under the operation of the recently enacted pure food laws, to insure the purity of articles of food and drink imported into the United States.

The paper was discussel by Mr. Waldemar Lee, Dr. W. J. Williams and Mr. Doolittle.

A vote of thanks was passed to the speaker of the evening for his interesting and instructive paper. Adjourned.

EDW. A. PARTRIDGE, *Secretary.*

Committee on Science and the Arts.

(Abstract of proceedings of the stated meeting held Wednesday, Nov. 7th, 1906.)

MR. HUGO BILGRAM in the chair.

The undermentioned report was adopted:

(No. 2379.) *Detector for Electrical Oscillations.* Louis H. Walter and Prof. James A. Ewing.

This report is reserved for publication in full.

Briefly, the device is one for detecting and measuring oscillating electric currents of high frequency and small volume; a quality which enables it to be used as a receiver in wireless telegraphy, for which service, the Committee report that it possesses all the qualities desired for successful operation. The award of the John Scott Legacy Premium and Medal is recommended to the inventors. *(Sub-Committee:* Thos. Spencer, Chairman.)

The following report passed first reading:

(No. 2394.) *The Monarch Engine Stop and Speed Limit System.* Consolidated Engine Stop Co., New York. (Laid over for one month under the rules.)

The following protest was made:

(No. 2382.) *Etch-Powdering Machine.* Louis E. Levy, Philadelphia. Applicant presented and filed with the Committee a letter of protest against the awards of the Committee in this case.

A motion to reconsider the Committee's action was offered by Mr. H. F. Calvin, and seconded by Dr. Edward Goldsmith. Action thereon will be taken at the stated meeting of December 5th inst.

WM. H. WAHL, *Secretary.*

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, November 21st, 1906.)

DR. EDWARD GOLDSMITH in the Chair.

Present, fourteen members.

Additions to membership since last report, seven.

Mr. Edwin Swift Balch read a paper on "The Survival of the Shortest and the Easiest in Language."

The speaker made a plea for the simplefication of the spelling of many English words—especially such as are extensively employed in trade and commerce—with the object of securing a wider use of English in the commercial world. He especially urged the adoption of the reformed spelling by the commercial and trade journals.

The paper was discussed by Mr. Henry F. Calvin, Dr. Edw. Goldsmith, Dr. Wm. H. Wahl, the author and others.

Mr. Harvey M. Watts, of Philadelphia, presented a communication entitled "The Why of the Weather."

Mr. Watts discussed the general causes of weather and climate in the light of the most recent advances in meteorology, showing the interdependence of weather conditions the world over, and what are the definite factors in the extraordinary variations which occur in the weather and climate from year to year and over long-range periods. The speaker's remarks were freely illustrated with the aid of lantern slides.

The communication was discussed by Messrs. Balch, Calvin, Goldsmith, Wahl and the author.

By vote, the thanks of the meeting were extended to the two speakers of the evening. Adjourned.

WM. H. WAHL, *Secretary.*

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DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

Dr. H. W. Jayne, Chairman; Mr. Edwin Swift Balch, James Christie, Dr. Persifor Frazer, Mr. Louis E. Levy, Committee on Publications;

with the Assistance of

Dr. Wm. H. Wahl, Secretary of the Institute.

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